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ELECTROCHEMICAL AND METALLURGICAL INDUSTRY

A Monthly Journal of Electrochemistry and Chemical and Metallurgical Engineering

VOLUME VII

From January to December 1909

436832

NEW YORK

ELECTROCHEMICAL PUBLISHING CO.

INDEX TO VOLUME VII.

GENERAL ALPHABETICAL INDEX.

*Entries from the Synopsis of Periodical Literature are indicated by S. (Synopsis); from the Analysis of Current Electrochemical, Chemical and Metallurgical United States Patents by P. (Patents); from the Digest of Electrochemical United States Patents Prior to July, 1902, by D. (Digest). Illustrated articles are indicated by *.*

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Electrochemical and Metallurgical Industry

VOL. VII. NEW YORK, JANUARY, 1909 No. 1.

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH. D.....*President*
E. F. ROEBER, PH. D.....*Editor and Secretary*
C. E. WHITTLESEY.....*Treasurer*

Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, JANUARY, 1909.

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Oliver Wolcott Gibbs.

In Oliver Wolcott Gibbs the chemists of the United States have lost one of their most beloved masters and leaders. Though he obtained his early chemical training in Germany and France, he was an American with all his soul, and though brilliant as a leader in chemistry, he was also a broad-minded American citizen, as evidenced by the part he took in the foundation of the Union League. Dr. Gibbs was president of the National Academy of Sciences and a past-president of the American Association for the Advancement of Science.

Nineteen Hundred and Eight.

After the general industrial depression of the past fifteen months it is to be hoped that in the industrial history of this country the year 1908 will be remembered less on account of this depression, but rather as the year at the end of which resumption of business set in and a new era of industrial activity started. It is certain that the chemical industries of this country have been less affected by the general crisis than other industries. On the other hand the metal industries have suffered very severely from the depression. Perhaps the most interesting feature of the metal market—because evidently of a permanent nature—is the drop of the price of aluminium so that it is now practically in line with copper; this will undoubtedly result in many new applications of aluminium; it is competing not only with copper (especially for electrical purposes), but with tin (tinfoil). In view of the enormous extent to which aluminium is found in nature it is really a common metal and its price has now been adapted to common uses.

* * *

The time of depression has been a suitable one for overhauling the works both in equipment and management, and many metallurgical and chemical works have made the most of this opportunity. Perhaps the most interesting development in modernizing metallurgical works—and a development in which this country may justly rejoice, as it is specifically American, and Europe has not yet risen to its opportunity in this field—is the continued success of the Gayley dry-blast process in its application in several blast furnace and now also converter plants. The first introduction of this process certainly required American pluck and it has been rewarded by a success beyond all expectations. It is also a peculiar case of metallurgical theory lagging behind practice.

* * *

In electrochemistry the greatest activity has been in electric furnace work. The ferroalloy industry is now established on a large scale in this country as well as in Canada, but as to prices the ferrosilicon market has been in a bad condition for the producer. On electric steel refining we comment in a separate editorial in view of the great importance of this

carbide. The carbide industry is steadily progressing along conservative lines, the use of the acetylene-oxygen flame, both for welding and for cutting metals, now attracts deserved attention, and seems to have a good future. The carborundum and artificial graphite industries are in a flourishing condition. The nitride industry still suffers from the lack of applications of boron. Its use as a refining agent in metallurgical and chemical works seems, however, very promising in many cases and has formed various inventors. Mr Betts' proposition on the metallurgy, described under "Recent Metallurgical Patents" in this issue, is interesting in this respect. "Silundum," which is now made commercially in Europe, as described elsewhere in this issue, appears to be in some way related to what is called siloxicon in this country. Deflocculated graphite with its enormous field of applications appears to become the crowning success of Mr Acheson's wonderful life work. The "monox" industry—which looked so promising a year ago—appears to have been buried, temporarily at least, as a direct result of the financial crisis.

* * *

As to electrolytic processes, nothing of a startling nature is to be reported. The existing plants are doing well. The electrolytic copper refineries have suffered, however, with the whole copper industry from the financial depression. The Townsend cell for making caustic soda and chlorine has proven so successful on a large scale that the Niagara works of the Development & Funding Co. are to be very considerably enlarged. Quite a number of inventors appear to be interested in the use of electrolytic chlorine for detinning tin scrap. With the enormous growth of the tin-can industry, detinning also has grown very considerably, and the new process of chlorine detinning seems to have distinct advantages compared with the older electrolytic detinning process.

* * *

Finally, we may say a few words as to electric discharges through gases. In this class we put together a number of very different reactions. Thus, ordinary air, being essentially a mixture of oxygen and nitrogen, yields very different products when subjected to the silent discharge or the arc discharge. In the former case we have ozone production by the reaction $3O_2 = 2O_3$, in the latter case we get combination of nitrogen with oxygen, and can make nitric acid or nitrates. These reactions are still quite mysterious. In the case of ozone formation, we may be sure to have a specifically electric effect and it seems not to be impossible that it is essentially a photoelectric effect due to ultra-violet light. On the other hand, the formation of nitrogen oxide by the arc discharge had been looked upon for a long while as a purely thermal (electric-furnace) reaction, the arc having no other effect but to produce the required high temperature. It seems now that this is wrong, at least within certain temperature limits; this is encouraging as it means the possibility of getting better outputs than had been thought theoretically possible under the old assumption. Ozone has been used on a large scale in the past in this country for flour bleaching and for producing certain chemical reactions, like the oxidation of camphor to camphin, while abroad ozone is also used largely for sterilization of water and air. As to the production of nitric acid from air by arc discharges, the continued success of the Birkeland-Eyde process, with cheap power in Norway, and the apparently even greater success of the Badische Anilin and Soda Fabrik in this field are of chief significance. This country is more concerned, however, with the other method of fixation of atmospheric nitrogen, namely, in form of calcium cyanamide from carbide, in view of the very large plant which is now being erected at Niagara for this purpose.

Steel Refining in the Electrical Furnace.

It is in the field of steel refining that electrometallurgy is now making the most striking and most important advances. This has not been an evolution of the steel industry from within, but an invasion of the field from without. Not only were the pioneers of this development electrochemical engineers rather than practical steel men, but in view of the skeptical and reluctant attitude of the existing industrial steel plants, these pioneers were forced to erect their own electrical steel works independent of the existing industry. Thus Héroult installed his own steel plant in connection with his aluminium and ferro-alloy works, Kjellin had his own induction furnace steel plant in Sweden, Stassano erected quite large works of his own in Turin, and now Girod is building a special steel plant of a size which should surprise any doubting Thomases, as Dr. Richards says in his description of these works elsewhere in this issue. This was a case of necessity; the attitude of the steel industry made this independent movement necessary to demonstrate to an unwilling public the practicability of the electric furnace process. But it is fortunate that this independent development appears to be about over now and that existing steel works are taking up the electric processes. The electric furnace processes themselves must benefit thereby just as well as the steel industry, and further evolution must be based on sound and healthy coöperation between electric furnace engineers and practical steel men. It cannot be doubted that the Héroult process derived much benefit from the experience gained at the Lindenberg and other old steel works where it has now been in commercial operation for a number of years. It is equally evident that the induction furnace has been changed into a more practical piece of apparatus for steel refining by the commercial evolution at the old Roechling works.

* * *

In the November and December issues of last year we published statistical lists of the electric steel plants now in operation or in course of erection in Europe, and it is interesting to give here a summary of these tables. There are now in operation or course of erection to 19 Héroult furnaces of an aggregate charge capacity of 63,300 kg, and 5 Héroult furnaces the capacity of which has not yet been definitely decided; 11 Stassano furnaces of an aggregate capacity of 16,900 kg; 8 Girod furnaces with a capacity of 34,000 kg; 10 Kjellin induction furnaces with a capacity of 21,500 kg, and 10 Roechling-Rodenhauser modified induction furnaces with a capacity of 29,200 kg. The above figures include 2 Héroult furnaces in this country, the other 22 being abroad. The furnaces of the other types are all in Europe. There are, however, some small Colby induction furnaces in operation in this country; one, chiefly for demonstrating purposes, in Niagara Falls. Two

things are evident from the above figures. First, that electric steel refining is beyond the experimental stage. Second that this country has been lagging in this development behind Europe.

* * *

There is clear evidence, however, now of a change of attitude of the existing steel companies of this country toward the electric furnace. One of the most interesting signs of the time is the testimony just given by Mr Charles M. Schwab before the Ways and Means Committee on the tariff hearings. We quote from the very full report in *Iron Age*. Mr Clark asked the question, "whether in your judgment the time has come when those rapid changes in the very expensive business of building these [open hearth] plants have reached their limit, or whether there is a prospect of improvements being constantly made that will later wipe out that process [open-hearth] and cause the throwing away of these big plants and building new ones?" Mr Schwab answered, "I think that is true. The open hearth process has been developing during these past 10 years. It was not believed it would make any material change in the plants except for special things. The demand for quality has made it of such a character that practically all steel must be made by the open hearth process. We have taken another step in advance which has been developed by the Germans, and that is the electric method of producing steel, which is an advance again over the open-hearth, that I am certain, in the next 10 years, or probably quicker, depending upon the rapidity of the development, will probably make all open hearths practically useless." Clearly Mr. Schwab believes that the future belongs to the electric steel furnace, though we hardly believe that his answer has been correctly understood by the reporter. Nobody who has first-hand knowledge of the electric furnace process believes that the electric furnace is to replace the open hearth. On the contrary, they will work side by side, and the electric furnace will give a new lease of life to the Bessemer converter. What Mr. Schwab probably has said is that all existing open-hearth and Bessemer converter plants will be forced within the next 10 years to install electric furnaces for further refining of the steel from the open-hearth and converter. In this conviction all people who are best informed and best able to judge, agree with Mr. Schwab. This also agrees with the following question and answer from the testimony. Mr Clark asked: "Well, you are able to get your product out cheaper on account of these?" Mr Schwab's reply was: "No, we are not. You do not get it cheaper. These processes have not been for the purpose of cheapening the product, but of bettering the quality. Each betterment of quality has added to the cost. Naturally electrically-refined steel will be somewhat more expensive than present steel, but its quality will be very much higher. The consumer will get steel of crucible steel quality at a cost only slightly exceeding that of ordinary structural steel."

* * *

The reason why the electric steel furnace will surely not displace the open hearth or the Bessemer converter is that it is considerably cheaper to make steel in two steps in the open hearth (or in the converter) and refine it in the electric furnace, than to make it in the electric furnace alone in one step. In the latter case the power cost would be prohibitive. Both the open hearth and the Bessemer converter are excellent metallurgical apparatus, and it would be most foolish not to make full use of what each has to offer in these particular metallurgical fields. But the point is that it becomes more evident that for many purposes, for instance for railway, bridge, and ship steel, or wherever large tonnages are required, it would be folly to attempt to make steel in the electric furnace alone, when it can be made cheaper in the converter or in the open hearth furnace. Therefore that the electric refining furnace, to which the steel is supplied in the electric furnace to which it is first brought in the open-hearth or converter, the power required is small and the cost of electric refining is small. The net result of the electric refining process is a steel product of very much better quality at a slightly higher cost.

* * *

Naturally as the open hearth process is simply a preparation for the electric refining process, it will be found preferable to make certain changes from present practice where the open hearth steel is the final product. Thus Dr Heroult's method of operation is to extend the open hearth process to the point when the steel is dephosphorized to the desired degree, it may then be highly oxidized, but this does not matter, as the steel is to be treated now in the electric furnace. There the steel is deoxidized (which is possible on account of the reducing atmosphere of the furnace), the sulphur is reduced and the steel is recarbonized to the desired degree. The desulphurization accompanies the deoxidization and the remarkable success of desulphurization is due to the formation of calcium sulphide, which is a specific electric furnace reaction. In this way it is possible to get a final steel product in which the sulphur and phosphorus are reduced to any desired degree. Of course, the electric power and the attendance cost some money, but on account of the possibility of using large units (entirely different from crucible steel practice) the cost of attendance per unit of output is low, and if the steel comes in molten form into the electric furnace, the power required is small. However, the easy removal of phosphorus and sulphur are not the only advantages of the process. Another important advantage is the great uniformity and homogeneity of the product, its freedom from oxides, gases, or slag. This fact will make electric refining highly desirable even in cases where steel is made from low phosphorus and low sulphur pig in the open-hearth. Cuban ores have placed such pig iron at the disposal of a few fortunate steel companies. Of course, in such cases the electric furnace treatment will be less expensive. In any case the cost depends on the reactions desired and the time needed for the reactions.

* * *

Finally it may not be amiss to refer briefly here to two special developments in the electrometallurgy of steel. One is the Lash-steel process, fully covered by the paper of Mr Fitzgerald in our December issue. This process appears to bring the problem of making steel directly from the mineral in solution as a special case. The other development is the annealing and tempering furnace, using a fused bath in which the articles to be treated are placed. It has been very successfully worked and is now being introduced in this country. The nicety of temperature adjustment and the almost perfect constancy of the temperature throughout the whole bath are indeed remarkable. On the whole the outlook of the electrometallurgy of steel is exceedingly encouraging. While the advance has been made chiefly abroad in the past, there is no doubt that when the

[illegible] industry enter the procession with their characteristic [illegible] will soon be leading the world.

Electric Smelting of Iron Ore.

We [illegible] the electric furnace for reduction of iron [illegible] cannot compete commercially with the blast furnace, for reasons which we have pointed out repeatedly in these columns. Local conditions may make iron ore reduction in the electric furnace practicable at special places—namely, wherever conditions are favorable to the production of cheap electric power and unfavorable to blast furnace practice. In the latter respect lack of coke may be the determining factor, if only charcoal or peat-coke is available, both being well suited for reducing agents in the electric furnace. There are localities which answer these requirements; in order not to go too far away, we may mention California and sections of Canada. The electric furnace for smelting iron ore has, therefore, decidedly more than a merely scientific interest, and Mr. Joh. Harden's able discussion of the subject, which will be found elsewhere in this issue, will prove interesting. Mr. Harden's point of view is to compare directly electric-furnace and blast-furnace working; he compares the cost if the reaction is the same in both cases. We may, however, also look at the matter in a different way and ask whether it is not possible to so change the method of working as to get in the electric furnace a reaction somewhat different from that in the blast furnace.

* * *

That there is some wisdom in putting the question in this way follows from the kindred problems of steel refining. We can use the electric furnace simply as a melting apparatus; then the reaction in the electric steel furnace is essentially the same as in the crucible process and the superiority of the electric furnace is simply due to the possibility of using large units with a reduced cost of apparatus and attendance. But we can go further. As has often been explained in this journal, we can use the electric furnace for refining steel by means of reactions which are impossible with the open-hearth and the Bessemer converter; and in the last analysis these possibilities will be found to be due to two causes; first, the higher temperature available in the electric furnace, and second, the possibility of carrying out the reactions in a neutral or reducing atmosphere, in absolute contradistinction to the oxidizing atmosphere of ordinary metallurgical practice. To make the utmost of these possibilities and not simply to imitate crucible steel practice, electric furnaces must be the aim of those who are developing electric steel processes.

* * *

As to reduction of iron from ore in the electric furnace, the chief difference between the chemical reactions in the blast furnace and in the electric furnace lies in the fact that in the latter there is no oxygen from the blast and the carbon is simply a reducing agent. Theoretically less than one-third as much carbon is required in the electric furnace as in the blast furnace. This has important consequences. The blast furnace is essentially a producer gas producer, that is, in the blast furnace it is impossible to burn the carbon to dioxide, since any dioxide formed, when coming in contact with free carbon, will form again carbon monoxide. For this reason blast furnace gas must contain considerable amounts of monoxide. The electric furnace is not subject to the same limitations. It would be possible by using a sufficient amount of carbon to so run the electric furnace as to get a gas as rich in monoxide as blast-furnace gas and, of course, this gas could be used just as well for running gas engines. But it would be wrong policy to do this. The electric furnace process will be the more efficient the more complete the oxidation of carbon to carbon dioxide within the furnace itself. It is therefore very important to reduce the quantity of carbon to a minimum. On this account and on account of the higher temperature obtainable and its more complete control, the electric furnace offers possibilities which the blast furnace has not. The Sault Ste. Marie experiments of the Canadian Government, a few years ago, have proven the possibility of elimination of sulphur, of complete control of silicon, of smelting titaniferous ores, etc. But there is still room for much purely chemical research, and when this is undertaken the utmost attention should be paid to gas analysis, which has not been done in the past. Further, there is still much to be done in evolving a proper furnace design suited for this particular purpose. In this respect we hope that Dr. Haanel's present trip to Sweden to examine for the Canadian Government the electric furnace of Messrs. Gronwall, Lindblad and Stalhane will yield interesting and valuable information.

The Situation in the Iron and Steel Industry.

The American iron trade has shown a conformity, in prices and production, with the 20-year cycle in which trade generally has been discovered to run. That 20-year cycle in general business found its nodal points in the panic years 1873 and 1893, and the iron trade conformed. The year 1873 did not, it is true, show diminished pig iron production, but the next three years showed successively declining production, and it was not until two additional years had elapsed that the production of 1873 was passed. The year 1893 itself showed diminished production. Both 1873 and 1893 were years of sharply declining prices. Each of these panic years was followed by a period of several years of depression. We spoke of these panic years as nodal points; at first glance one might think that a panic year is the last that should be selected as a nodal point—a point of rest—because panic suggests excitement, but the idea is that these years were years of transition from activity to quiet. A citation of railroad statistics will suffice: the year 1873 was the third successive year of decreased railroad building, but in the two following years the new mileage successively decreased further; the year 1893 was the fourth year (barring a negligible increase in 1892) of successive decrease in railroad building, but in the three following years railroad building continued to decrease. These panic years lay midway in a decline in activity.

* * *

A review of the movement of the iron trade year by year, since 1893, would show conclusively that, barring the most minor discrepancies, the course of the iron trade has duplicated the course it followed after 1873. The conformity is startling, but it would be tiresome to adduce the historical proofs in this connection. The swings in the iron trade since 1893, then, are not to be taken as haphazard occurrences, since they were a duplication of what had taken place once before, 20 years earlier. Another circumstance encourages the inference that

there is a law underneath these workings. After 1873 and 1893 there was a period of stagnation, lasting well through 1878 and 1898. In 1879 and 1899 there occurred a wonderful boom. Prices soared to wholly unexpected heights, and productive capacity was strained to the utmost. As a result, the movement played out quickly, prices breaking sharply in 1880 and 1900, afterwards recovering more slowly to high points in 1882 and 1902. In 1882 a decline started early in the year, while in 1902 the decline began later in the year. In each case the decline was much more gradual than the preceding decline, and the recovery which ensued was gradual, but very substantial. The recovery, in the case of the more recent period, led us into that period of remarkable sustained activity, 1905-6-7. The point of particular interest in this movement is that the swings have grown less and less violent, and have covered longer and longer periods of time. The 1899 boom was short; the 1902 boom was longer; the three-year period 1905-6-7, was too long, and its business was conducted in too orderly a manner, to permit it to be considered a boom at all; it had the substance of several booms combined, without their intermediate periods of reaction. There is reason to hope that the panic of October, 1907, was not a great panic like those of 1873 and 1893, because it fails to show the periodicity. There is reason to hope that it was not so because the iron trade was establishing a tendency toward a longer and longer swing. There is reason to believe so, because the elements of panic, of unreasoning fear, have been clearly observed to be absent from the trade. Were 1907 a replica of 1873 and 1893 it would be proper to expect several years of declining prices and diminishing production, but the signs of the year 1908 do not so indicate.

* * *

As to production, it is to be observed that pig iron production in the second half of 1908 has exceeded that of the first half by about 2,000,000 tons, or by almost 30 per cent, and that this has been the case despite the fact that much work financed and undertaken before the October panic was continued into 1908. The leading structural interests worked for months in this past year almost wholly on contracts thus furnished. Had it not been for this and other work which so lapped over, the first half of 1908 would have shown still smaller production and the second half would have shown a greater appearance of recovery by the emphasis given to the contrast. It is obvious that the trade has been steadily jogging along the road of recovery. We have compared second half production with first half; the comparison can be taken in detail. June was a month of very small production, and each following month has shown a successive increase in tonnage. That there has been steady progress is certain, and it is along the road of recovery. That the road can be traveled, in the present manner, until the point of previous record production is reached, is not so certain, while that it can pass this point, and attain a new tonnage rate, conforming to the increased capacity which is coming into being, is still less certain.

* * *

Let us review our measurements: pig iron production has been as follows:

Year.	Gross tons.
1901	15,878,354
1902	17,821,307
1903	18,009,252
1904	16,497,033
1905	22,992,380
1906	25,307,191
1907	25,781,361

A little scrutiny shows that there has been an average gain of 2,000,000 tons a year. It was just so from 1901 to 1902; 1903 ended with a slump, and 1904 contributed further to the backset, but 1905 emerged with a tonnage sufficient to make up the expected gain of 2,000,000 tons each year, barring the loss of a single million, and 1906 contributed its 2,000,000 tons, with a trifle to spare. It was easily observed that had the production rate of October, 1907, been continued through that year there would have been the regular gain of 2,000,000 tons over the preceding year. The progression has been rudely interrupted, and the year 1908 will show an output of only about 15,850,000 tons, a decline of 9,000,000 tons from the actual production of the calendar year 1907, a decline of 11,500,000 tons from the gait which 1907 maintained during its first 10 months, and a deficiency of more than 12,000,000 tons from the capacity which was in full operative condition. It is, finally, 16,000,000 tons less than the prospective capacity, through plants now almost completed and which would have been completed before this had work been pushed. Evidently the certainty that the iron trade is now steadily moving along the road of recovery cannot promise that the pace can be maintained until the goal of full activity has been reached.

* * *

During the period of intense activity which culminated in October, 1907, with a pig iron production rate exceeding 28,000,000 tons a year the adage was adopted, "Steady prices make steady demand," but there was evidence that the function of steady prices was really that of leading to anticipation of wants, because waiting a while did not promise the lower prices which in the past usually followed periods of heavy demand. When the reaction came, it became evident that wants had been anticipated, and the fall was the more sudden. The iron and steel industry has made great strides in processes and devices in these years. The cost of making steel, measured not by wage rates, changing in their own amount and in the quantity of service rendered for them, but by actual expenditure of fuel and mental and manual energy, has been greatly decreased. Through influences without the trade, and to a great extent through influences within the trade, a realization upon these achievements through the inviting of increased demand with lower prices has been denied to the industry, although it stands in need of this assistance. If there is not an improvement in this respect, a retarding influence is likely to be felt more and more, as the industry progresses on its road toward the engagement of the full tonnage capacity. The plants are in position to make new records of efficiency and show new low records of cost, if the facilities are afforded them. Whether that tonnage demand can be gained through the medium of lower prices is doubted by many good judges of the trade, but considering the efficiency the individual plants would show if run at full capacity, and the enormous capacity which is in existence, or on the verge of completion, compared with the present measure of demand, it may at least be suggested that the question still deserves serious consideration.

International Congress of Applied Chemistry in London.

[illegible] Congress of Applied Chemistry [illegible] May 31 to June 2, 1909. The [illegible] Henry Ramsay, active president, [illegible] Worthington, Mr. [illegible] general secretary and [illegible] Chandler Bates and [illegible] Wilson are treasurers. Dr. [illegible] Wiley at Washington, D. C., has been appointed [illegible] American committee.

[illegible] following sections and sub-[illegible] The American chairmen of the sub-committees who will [illegible] charge of all papers and matters relating to the sec-[illegible] which they are assigned, are as follows: (1) Analytical Chemistry, Charles Baskerville, College of the City of New York; (2) Inorganic Chemistry and Allied Industries, J. D. Darrah, Solvay Process Co., Syracuse, N. Y.; (3a) Metallurgy and Mining, John Hays Hammond, 71 Broadway, New York City; (3b) Explosives, Charles E. Munroe, George Washington University, Washington, D. C.; (4a) Organic Products, William McMurtrie, 480 Park Avenue, New York City; (4b) Coloring Substances and Their Uses, Bernard C. Hesse, 90 William Street, New York City; (5) Industry and Chemistry of Sugar, C. A. Browne, 80 South Street, New York City; (6a) Starch Industry, I. B. Wagner, Heyworth Building, Chicago, Ill.; (6b) Fermentation, Francis Wyatt, 402 West Twenty-third Street, New York City; (7) Agricultural Chemistry, C. G. Hopkins, University of Illinois, Urbana, Ill.; (8a) Hygiene and Medical Chemistry, Reid Hunt, United States Public Health and Marine Hospital Service, Washington, D. C.; (8b) Pharmaceutical Chemistry, Joseph P. Remington, 1832 Pine Street, Philadelphia, Pa.; (8c) Bromatology, W. D. Bigelow, Bureau of Chemistry, United States Department of Agriculture, Washington, D. C.; (9) Photochemistry, L. H. Baekeland, Yonkers, N. Y.; (10) Electrochemistry and Physical Chemistry, W. D. Bancroft, 7 East Avenue, Ithaca, N. Y.; (11) Law, Political Economics and Legislation, with Reference to Chemical Industries, Charles B. Dudley, Altoona, Pa.

All who are interested in promoting the applications of chemistry are eligible for membership in the congress. The present membership is £1 for men and 15s. for women. American chemists intending to become members should send their check for $5 either to the chairman of one of the sections or direct to the chairman of the American committee at Washington, who will transmit same to the proper official in London.

Those intending to present papers should write to the chairman of the section to which the paper belongs. Papers should be neatly typewritten on thin paper and be in the hands of the chairman of the American committee not later than April 1, [illegible] prior to be forwarded to London for translating and printing.

Those who attend will be amply rewarded for membership by receiving the publications, which will be in several large volumes and will contain the latest ideas and discoveries connected with the progress of applied chemistry. The publications of the last congress consisted of four volumes containing articles by experts upon all branches of applied chemistry. The proceedings of the sixth congress numbered seven large volumes. The proceedings of the next London congress will probably surpass all previous ones in the quality and quantity.

Pittsburgh Meeting American Institute of Chemical Engineers.

The [illegible] meeting of the American Institute of Chemical Engineers will be held in Pittsburgh, Pa., on Dec. 28 and [illegible]. All the [illegible] will be held at the Carnegie Technical Schools. Headquarters will be at the Hotel Schenley.

[illegible] Monday morning, Dec. 28, beginning at 9:30. The program of the papers to be presented at this session is as follows:

"Steam Power Plant Economics from the Standpoint of the Chemical Engineer," by William M. Booth.

"Technical Coal Analysis," by Edward Gudeman.

"The Chemical Aspect of Impurities which Cause Scale and Corrosion of Steam Boilers," by J. C. William Greth.

"Testing and Performance of Steam Generating Apparatus," by A. Bement.

"The Examination of Flue Gases in Boiler Tests," by H. August Hunicke.

"The Utilization of Low-Grade Fuels in the United States" (illustrated by photographs and samples of peat-coke and by-products produced by the Ziegler process for coking peat and ignite), by O. K. Zwingerberger.

"Producer-Gas Installations," by Ernest Schmatolla.

"Work of the United States Government Fuel-Testing Plant at Denver, Col.," by A. W. Belden.

In the afternoon an excursion will be made to the Duquesne plant of the Carnegie Steel Co. In the evening dinner will be taken at the Hotel Schenley, after which the business meeting will be held, followed by the presidential address of Dr. Samuel P. Sadtler and an illustrated lecture by Mr. Richard K. Meade on the heating of industrial furnaces with pulverized fuel.

The program of the papers to be presented at the Tuesday morning session is as follows:

"Modern Electrical Resistance Pyrometry," by Edwin T. Northrup.

"Chemical Specifications for Sulphite Pulp," by J. A. DeCew.

"An Apparatus for Testing Liquified Ammonia Gas," by F. W. Frerichs.

"The Sanitary Condition of the Southern End of Lake Michigan," by Herbert Brewster.

"Cement Manufacturing Methods," by J. G. Dean.

"Some Experiments with the Ferric Iron Contact Method of Making Sulphuric Acid from Smelter Fumes," by Thorn Smith.

In the evening of Tuesday, Mr. William M. Grosvenor will lecture on "Dryer Calculations and Dryer Design."

For Tuesday afternoon several excursions will be arranged. Permission has been obtained to visit the following plants, the date and hour of each excursion to be announced at the meeting:

Homestead and Duquesne plants of the Carnegie Steel Co.

By-product coke works of Carnegie Steel Co., at South Sharon, Pa.

Phoenix Glass Co.'s works at Monoca, Pa.

Pittsburgh Gas & Coke Co.'s by-product works at Glassport.

Coke plant at Uniontown of the H. C. Frick Coke Co.

Westinghouse Machine Co.

The laboratories and testing departments of the Carnegie Technical Schools will be open for inspection.

In connection with the meeting an exhibition will be made of chemical engineering apparatus and of drawings and photographs of such apparatus and installations. Among the exhibitors are: Cleveland Bronze & Brass Works, Davis Bournonville Co., Didier-March Co., H. W. Dopp Co., Fuller Engineering Co., Leeds & Northrup Co., George M. Newhall Engineering Co., Schutte & Koerting, Edward R. Taylor, Vulcan Iron Works, and the Zaremba Co.

Iron and Steel Institute.

The council of the Iron and Steel Institute have awarded the Bessemer Gold Medal to Mr. Alexandre Pourcel, an eminent French metallurgist. The Bessemer gold medal is awarded annually for services to metallurgy, and it is for his investigations in the manufacture of ferromanganese and for his work on the thermal reactions involved in the manufacture of iron and steel that Mr. Pourcel, who was elected a member of the

Iron and Steel Institute in 1875, a few became the recipient.

The council have appointed Mr. G. C. Lloyd to the vacancy occasioned by the death of Mr. Bennett H. Brough, secretary of the institute. Mr. Lloyd is at present secretary of the (Brit.) Institution of Electrical Engineers, having been appointed in 1904. In 1900 he was appointed assistant to Mr. Brough, at the Iron and Steel Institute, a position he held until his appointment to the Electrical Engineers.

The council have at the same time offered the assistant secretaryship to Mr. L. P. Sidney, who was appointed as Mr. Brough's assistant in succession to Mr. Lloyd in 1904. Hither to there has been no formal offer of this description.

William M. Habirshaw.

Since the late Mr. Habirshaw was been truly called a pioneer of the modern generation of chemical engineers, the fitting tribute paid to his life work, at the recent annual meeting of the Chemists' Club by a special committee, consisting of Dr. T. J. Parker, Dr. C. F. Chandler and Dr. G. A. Goldschmidt, should prove a source of inspiration.

The sketch of the life of Mr. Habirshaw from the pen of Dr. T. J. PARKER is here with reproduced.

WM. M. HABIRSHAW.

"Wm. Martin Habirshaw was born in February, 1835, at 197 William Street, New York City. His early education was obtained in New York and later in Europe, but Mr. Habirshaw was essentially a self educated man. Leaving the U. S. Navy, where he had served as an engineer previous to 1873, he opened a laboratory for commercial analyses and consultation at 36 New Street, and later removed to Fulton Street.

"How long previous to the year named this laboratory had been in operation we cannot learn, but it had been there for several years. This laboratory was maintained until 1876 or 1877, during which period he did the bulk of the commercial analyses required by the chemical industry so to obtained from independent analyses. Products such as bleaching powder, soda ash and wood pulp were analyzed and to fact the work embraced the whole range of commercial analysis as then known.

"He was a Fellow of the Royal Society, charter member of the American Chemical Society, a member of the Society of Chemical Industry and the Chemical Society of London, and an authorized chemist of the London Exchange. His service to the iron industry was of great value, and many of the improvements in its processes are due to him. He also rendered great service to the sugar industry and fertilizer chemistry. Mr. Habirshaw was probably the first of those whom we would now call a Chemical Engineer.

"Among other industries he gave his attention to the manufacturing alkali by the soda-ammonia process, and he had intended starting such an industry in this country on a large scale, but the capitalists interested with him had not sufficient faith in the future of the industry in this country to connect it with the foreign product.

"Mr. Habirshaw also devoted a great deal of his time to the application of electricity to metallurgy, and the experiments of such application. In this connection he produced many compounds which have been patented and used for many years.

"In 1887 he organized the India Rubber & Gutta Percha Insulating Co., of which he became president and general manager, with a factory at Twenty-fourth Street and Eleventh Avenue, New York City. In this factory was manufactured the compounds spoken of. Here also he devised many improvements in the machinery for the application of his compounds to electrical conductors.

"About 1890 this business was moved to Glenwood, in the City of Yonkers, where it continued to grow and to be carried on in most successful operation, its name having been changed to the Habirshaw Wire Co., on January 1 last.

"Mr. Habirshaw retained to the end his large interest in the company and gave it much of his personal attention. For several years his health had been failing and he was a great sufferer. Knowing that his active career was growing to a close, he organized and trained a corps of men who should be ready at any time to assume the work which he had so successfully directed since the organization of the company.

"Mr. Habirshaw was a man of delightful personality. He was fortunate in drawing about him men prominent in all walks of life, scientific, literary, artistic, army and navy men and financiers. Not only did Mr. Habirshaw take a keen delight in the practice of chemistry, but also in advancing the interests of chemists. He was never called on to assist a brother chemist, either financially or with advice, that he did not respond most generously. The profession of chemistry has suffered a great loss in his demise."

The Iron and Steel Market.

The closing month of the year has been a quiet one as regards market transactions. A dull December is normal in the trade, while the past three Decembers have been exceptions to the rule. In 1905 and 1906 the market was under such buying pressure that there was no opportunity for the usual lull while in 1907 the October panic had created such a disorganization as to make that no special dullness in December was noticeable. Consumers of pig iron and finished products wish to replace their obligations and stocks as much as possible against the closing of their books at the end of the year.

There has been a change in the attitude of producers as to the future of the trade, a feeling of confidence prevailing that 1909 has better things in store for the iron and steel trade than 1908 has afforded. No sudden increase in demand is looked for, but a steady progress toward a better plane of activity is expected. The railroads expect to increase their purchases gradually rather than suddenly. Some manufacturing establishments an increase in the general business activity in the country during the second half of the year.

While there is good ground for believing in the ultimate recovery that 1909 will record, there is nothing to warrant any decided speculative movement, and it is evident that conservatism will be the rule. There may be some improvement in the early part of January, but it is not likely that any great change in prices will occur before the spring months. The prospect for good business during the first half of the year is encouraging, but the profits will be small. Many of the finished products have not fallen to the lowest point, while the prices of pig iron, billets, sheets, tin plate and structural material have declined to those most commanding considerable lower percentage.

The conditions in all these lines is as large [illegible] of the year as at other seasons. Tin plate has [illegible] of its usual period, the mills now running on [illegible] for the tinplate industry and stocking other consumers [illegible] the spring rush.

There are no immediate prospects of any changes in prices. [illegible] was a substantial advance in pig iron late in October and during November, and the probabilities seem to be that the [illegible] will be held, for the time, without further [illegible]. In finished steel products there has been no movement [illegible] any advances while there is no particular reason to [illegible] decline. The leading producers are committed to [illegible] of prices and do not seem to expect any change except in the unforeseen event of some individuals changing their views and acting independently.

PIG IRON.

The Eastern pig iron market has advanced slightly since last report, while Chicago, Alabama and Pittsburgh present no change in prices. No. 2X foundry, delivered Philadelphia, is [illegible] 25 cents higher than at last report, at $17.25 to $17.50. Some Southern furnaces are still willing to sell at $13, Birmingham, for first quarter or first half, although many producers [illegible] to $13.50 for the later delivery. Chicago district furnaces continue to quote $17, a price which is more attractive [illegible] formerly, on account of the advance in Southern iron in November. The valley furnaces are quoting former prices, except on Bessemer, which seems to be established on a basis of $16.50, against $16 quoted in our last report. Foundry iron is $15.50 to $16, valley, basic $15.50, and forge $14.25 to $14.50.

BILLETS AND SHEET BARS.

The market has been very quiet, but shipments have been well maintained. Prices are firm, except that in the East there is still occasional shading on billets, concessions generally [illegible] amounting only to a fraction of a dollar. The regular market is $25 on billets and $27.50 on sheet bars, with certain concessions [illegible] freights.

FINISHED MATERIAL.

There has been further firming up in prices, and the whole [illegible] is now pretty well observed, there being occasional slight [illegible] in one or two lines. Light rails are sold at $23 to $24 at some of the rerolling mills, the official price of mills [illegible] light rails from new steel being $25. Official prices are as follows, f.o.b. Pittsburgh, except in the case of rails, which are f.o.b. mill:

Standard rails, $28 for Bessemer, $30 for open-hearth.

Light rails, $25.

Plates, 1.60 cents for tank quality.

Shapes, 1.60 cents for beams and channels, 15 in. and under, angles and zees.

Steel bars, 1.40 cents, iron bars, 1.50 cents, delivered Pittsburgh, 1.50 cents delivered Chicago.

Wire nails, 1.80 cents, wire nails $1.95.

Steel pipe, 42½ per cent. net for black, 35 per cent. net, for galvanized, 28 per cent.

Boiler tubes, 50 per cent. net for 2-in. lap welded.

A 20,000-H.P. Twin Tandem Compound Reversing Blooming Mill Engine.

[illegible] we learned of for the [illegible] type is the 40-in. blooming [illegible] Steel Co.'s Duquesne Steel Works. [illegible] mill was put in operation [illegible] Dec. 18, by members of the [illegible] Pennsylvania, the mill had not [illegible] engine.

[illegible] Hooppull & Co., which [illegible] reversing engine, intended [illegible] Jones & Laughlin Steel [illegible] weighing about 2,260,000 lb. It embraces a number of novel features, particularly in the valve mechanism and in the accessibility of parts.

The engines are 44 and 70 by 60 and are designed to run at 100 to 150 r.p.m., developing 20,000 hp. The complete reversal can be accomplished in 15 seconds. During the inspection a copper cent stood on edge on the bedplate. While the specifications were quite rigid, the builders used about 400,000 lb. more metal than was called for, and, considering the engine's remarkable success, are well satisfied that they did so.

The mill has been running somewhat slack, blooming the 6000-lb. ingots in about 2½ minutes. When steel is available from the new open-hearth furnaces at Duquesne, now nearing completion, the time will be decreased to two minutes, giving the mill an output of about 80 tons an hour, or nearly 2000 tons in 24 hours.

CORRESPONDENCE.

Heat Conduction Through Furnace Walls.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—The paper by Mr. Carl Hering on the conduction of heat through furnace walls, published in your December issue, is exceedingly interesting and should be appreciated as an important first step toward the solution of the problem to calculate in advance the heat loss through the walls of a furnace. Mr. Hering's formulas permit the exact calculation of the heat losses through the walls of usual construction under the following assumptions: Firstly, that the heat conductivity of the walls is known (more exactly, as function of the temperature); secondly, that the temperatures of the inside surface and of the outside surface of the furnace walls are known.

Under present conditions, as a result of the existing lack of data, Mr. Hering's formulas can hardly be expected to be applicable for exactly predetermining the heat loss of a new type of furnace. But they should be useful in the hands of metallurgists for comparative estimates; for instance, if the behavior of a furnace is known and this is to be doubled in capacity, how much must we increase the furnace walls? Such questions may be answered on the basis of Mr. Hering's diagrams.

As to the first assumption, stated above, I was struck by the reference to Peclet's old work. It is very little known. Why not republish his figures?

As to the second point, it should be emphasized that the two temperatures in Mr. Hering's formulas are the temperatures of the inside and the outside wall surfaces themselves, not the temperature of the charge inside and of the air outside in contact with the walls. For there may be no thermal equilibrium at the contact surface. If we cool with running water we know there is a sudden drop of temperature at the surface and this drop depends on the speed of the water (see, for instance, J. W. Richards, your Vol. IV, p. 99, reprinted in the first volume of his Metallurgical Calculations). In the analogous electrical problem (conduction of an electric current through the wall) we have here not only the ohmic drop of voltage due to resistance, but an e.m.f. at the surface.

This brings us to the very important practical case of water-jacketed furnaces. Here the chilled slag, immediately formed on the walls, forms a natural refractory lining. When water-jacketed furnaces were introduced much fear was expressed that the heat losses would be prohibitive. But Mr. Herreshoff published long ago some tests on the amount of heat loss in feed water, and proved that only 5 per cent of the total heat was lost in water from jacket. Undoubtedly Mr. Hering's explanation is correct that this is due to the low thermal conductivity of the chilled slag. But it would seem highly impracticable to try to calculate in this complex case the heat loss by such formulas as Mr. Hering's. We must rely on empirical rules, although an endeavor should be made to place them on a more scientific, that is, rational, basis.

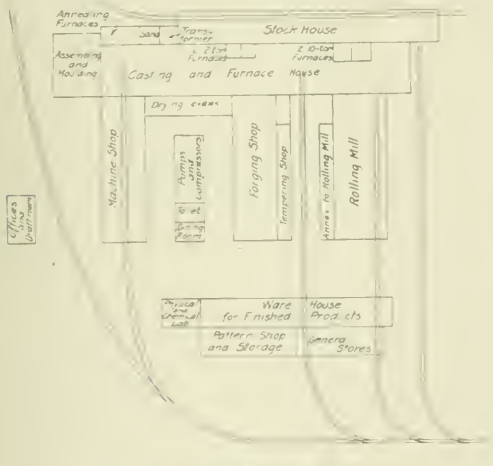
DENVER, COLO. METALLURGICAL ENGINEER.

The Largest Electric Steel Works.

By JOSEPH W. RICHARDS

Mr. Paul Girod, a native of Freyburg, Switzerland, started ten years ago at Albertville in the Savoy, not far from Mont Blanc, with one man as assistant and a 25 horse power dynamo, to utilize the power available in "*houille blanche*" (white coal, i. e., snow) for making ferro-alloys. This business has been transferred to Ugine (Savoy), where it has grown to splendid proportions, using up to 9,000 horse-power in seasons of high water. These products are now exported to all parts of the world. (See the article of Dr. R. S. Hutton, ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, 1907, Vol. V, page 9.)

More recently Mr. Girod has devised the Girod electric steel furnace, and has begun to manufacture steel. His furnace and its method of operation have been already described in this journal. (See our Vol. VI, pages 428 and 510, 1908.) He is now so sure of the absolute control which the electric furnace gives as to quality of steel, uniformity of working and cheapness as compared with the crucible process, that the Société Anonyme Electrometallurgique Procédés Paul Girod, with 5,000,000 francs capital is now building at Ugine, in Savoy, a



PLAN OF ELECTRIC STEEL WORKS

plant which may be regarded as the largest, most complete and altogether the pioneer electric steel plant of this new dispensation in the metallurgy of steel. The scale on which this plant has been designed will certainly surprise any doubting Thomases who have hitherto refused to "enthuse" over this new industry.

Here, as elsewhere, the industry has not been a development by steel workers, not an evolution from within the steel industry, but an invasion of the field from without, by technologists who had everything to learn about the making of steel. Stassano at Turin was a captain in the artillery. Heroult was a chemist busied principally with aluminium. Colby was a platinum refiner, Kjellin an electrical engineer, and Girod was a chemist who probably never saw the inside of a steel works until quite recently. His associates are chemists, engineers and machinists, but hardly any can be called "practical steel men" aside from their connection with the Girod plant. However, they are creating a new metallurgy of high quality steel. By using a finely equipped chemical laboratory, fully planned mechanical testing plant, and with minds fully receptive of new ideas and unfettered by old traditions, they stand a very good chance to introduce new life into the manufacture of fine and special steels. Here is the making of history in the metallurgy of steel, and the world which uses fine steels will profit immensely by their enterprise.

The new plant is expected to be in operation in March, 1909. Houses for the workmen are being built, 22,000 horse power of water fall is being harnessed, and in a few months a beautiful Alpine valley surrounded by snow-clad mountains will be the seat of an important and new type of steel industry. The annexed plan and description will give an idea of the magnitude of this undertaking.

Stock House.—For receipt and storage of steel scrap and furnace material of all kinds. It is 17.5 by 140 meters (58 by 460 feet) and equipped with overhead traveling cranes and magnetic lifting apparatus.

Furnace and Casting House.—21.5 by 165 meters (70 by 550 feet), provided with two traveling cranes of 2 tons capacity and two of 15 tons. Contains at present two 2-ton furnaces and two 10-ton furnaces. The latter will be normally operated at from 8 to 12 tons charge using current at 60 volts and 32,000 amperes. The normal output of these is reckoned at 50 tons per day, but there is room and corresponding works capacity for four times as many furnaces, and an eventual output of 200 tons per day. The smaller furnaces are intended particularly for making special and high price steels, the larger ones for carbon and nickel steels.

Transformer Building.—It is 10 by 10 meters (33 by 33 feet) in size, the current being transmitted at 45,000 volts over 40 kilometers (24 miles) from St. Gervais. We have not discussed with Mr. Girod the reasons for placing it at the point indicated, but it appears to us unnecessarily distant from the furnaces, entailing large expenses for the conductors. The large furnaces are nearly 300 feet from the transformers, and it would appear as if several small transformer stations in close proximity to each of the furnaces would have been more economical of aluminium and of power.

Sand Storage House.—10 by 10 meters (33 by 33 feet).

Drying-Oven House.—15 by 45 meters (50 by 150 feet). For core ovens and drying moulds.

Assembly Shop.—20 by 31.5 meters (67 by 105 feet). For assembling of moulds, making of cores, moulds, etc.

Annealing Shop.—10 by 20 meters (33 by 67 feet). Containing annealing furnaces for treating castings.

Machine Shop.—21.5 by 75 meters (70 by 250 feet). For lathes, planers and like machinery for finishing castings.

Forging Department.—21.5 by 75 meters (70 by 250 feet). Will contain a 600-ton hydraulic press for rough forging of 10-ton ingots, and eight power hammers of 3,000, 1,000, 500, 300, 200, 150, 75 and 50 kilograms respectively, driven by compressed air.

Tempering Shop.—As an annex to the forging shop 15 by 60 meters (50 by 200 feet).

Rolling Mill.—27.5 by 75 meters (90 by 250 feet). Will contain one train of 525 millimeters (20 inches) and one of 305 millimeters (12 inches). They will be electrically driven by an 800 horse power, three-phase motor using current at 2,500 volts.

Annex to Rolling Mill.—15 by 60 meters (50 by 200 feet), for storage of rolls, machinery, etc.

Pump and Compressor Building.—15 by 35 meters (50 by 115 feet). Will contain two compressors handling each 60 cubic meters (2,000 cubic feet) of air per minute and compressing to 5 atmospheres, one handling 20 cubic meters (700 cubic feet) per minute compressing to 15 atmospheres, and one of 20 cubic meters compressing to 7 atmospheres. These are all electrically driven. There will also be two rotary converters of 300 horse-power each, transforming the 2,500 volt 50 period, three-phase current into direct current of 500 volts for use by the electric railway traveling cranes, and other machinery.

Warehouse for Finished Products.—15 by 100 meters (50 by 325 feet). This is made particularly large because of the variety of products [illegible]

Experiments on Melting in the Induction Furnace.

By E. A. J. FitzGerald.

A casual consideration of the induction furnace suggests the impression that it would prove but an inefficient apparatus for the conversion of electrical energy into heat. The metal contained in the annular crucible presents a large surface by which heat can be carried off by radiation and conduction, as compared with furnaces of other types, and thus the question may be asked, "Why not give up the induction principle altogether?"

There are three methods by which a metal to be melted in a furnace may be heated electrically:

(1) By heating a suitable resistance with an electric current and thereby forming an arc, and then causing the metal by radiation ...

(2) By heating a substance in contact with the metal either by an arc or by passing the current through it and thereby transforming the heat into the metal by conduction.

(3) By causing the current to flow through the metal ...

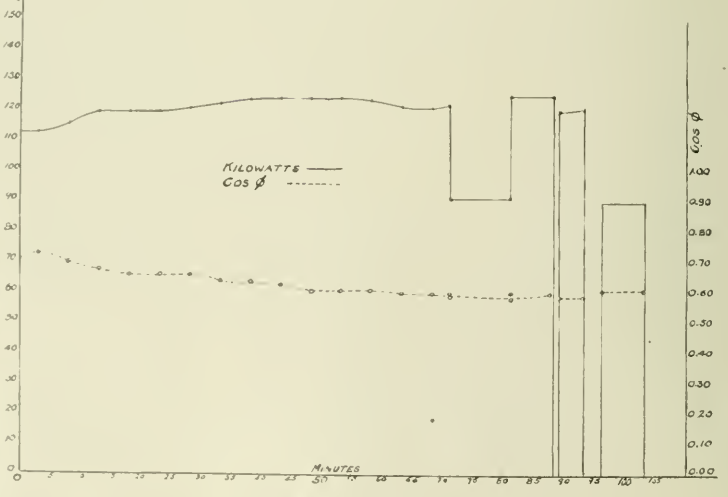
Theoretically when heat is generated in the metal by passing a current through it, the rate of generation is simply equivalent to the wattage of the current. Once a molten bath of metal is obtained the temperature may be held constant by feeding in cold metal, which will take up the heat given by the current as fast as it is generated. In this case the limit is fixed by the "punch" effect.

Now, in any electric furnace used for melting, of the total energy generated a part is used in fusing the metal and raising it to a certain definite temperature, and a part is radiated into space. All other conditions being the same the heat radiated into space while melting a ton of metal will be directly proportional to the time of melting, therefore the more rapidly the heat is supplied to the metal the less will be the heat loss by radiation and the higher will be the thermal efficiency of the furnace.

While a good deal of information can be found in reference to the induction furnace, which is a good example of heating metal by the passage of a current through it, there does not appear to be any published account of an experiment made with the object of forming some notion of its efficiency as a melting apparatus.

At the demonstration plant of the American Electric Furnace Company there are facilities for making such an experiment, and with the co-operation of Mr. T. Rowlands, the works manager, an experiment was made on the melting capacity of one of the furnaces installed there.

The 125-kilowatt furnace has a holding capacity of approximately 2000 pounds of steel, and pours about 1200 pounds at a time. The normal voltage of the primary coil is 525 volts, but by means of a regulating device used in connection with the transformer this voltage may be varied between 475 and 600 volts. There being some uncertainty as to the accuracy of the switchboard instruments it was considered desirable to calibrate



INDUCTION FURNACE EXPERIMENTS

these immediately after the experiment, and this was accordingly done by the courtesy of the Canadian Niagara Power Co., who used their standard instruments for the purpose.

Before the test run the furnace had been standing with a molten steel bath of about 850 pounds. As soon as the test commenced the pressure on the primary was raised to 580 volts.

Three minutes later charging was begun, the material of the charge consisting of 450 pounds of washed metal and 450 pounds of muck bars, or 900 pounds in all. The charge was completely melted in 68 minutes. The primary pressure was then cut down to 475 volts and 100 pounds of slag from the surface of the bath removed. The removal of the slag occupied about 10 minutes. The voltage was then raised and ferrosilicon and ferromanganese put in the bath. From the time of starting to add the alloys until casting was 12 minutes, but for 1 minute of this time the current was cut off to permit of making some adjustments of the electrical apparatus. The current was off for 3 minutes while making the first cast of 450 pounds and was then thrown on again for 7 minutes while preparing the ladle for the second cast of 450 pounds. There was no reason why the second cast should not have been made immediately after the first with it putting on the current again if the ladle had been ready.

In the following table is given an analysis of the time and energy consumption during the heat:

	Running Time in Minutes.	Kw Hours.
Preliminary heating	3	5.0
Melting	68	137.1
Removing slag	10	15.3
Melting finishing alloys	11	22.7
Heating before second cast	7	10.7
Total	80	191.4

Total charge.. 900 pounds.
Total time.. 1.72 hours.
Mean kilowatts while running.. 110 kilowatts.
Maximum kilowatts.. 125 kilowatts.
Energy consumption per ton (2240 lbs.).. 476 kw-hours.
Energy consumption per ton (2240 lbs.).. .638 hp-hours.

The curves show the kilowatts and the power factor throughout the run.

During the experiment the highest attainable voltage was used, yet the "pinch" effect was not obtained, so that this experiment unfortunately has not shown just where the limit lies. However, the results seem to be of sufficient interest to be worthy of publication and to show why the induction principle is one worthy of consideration in heating materials electrically.

FITZGERALD AND BENNIE LABORATORIES,
NIAGARA FALLS, N. Y.

Heat Conductance and Resistance of Composite Bodies.

BY CARL HERING.

The object of the present article is to treat of the manner in which heat travels through various forms of composite bodies, that is, through those consisting of layers of different materials having different conductivities, dimensions or temperatures. Some practical problems involving considerations in the calculation of the heat which will be conducted through them.

The walls of a furnace, which usually consist of layers of different materials, is an illustration of such a case. In underground flue furnaces, particularly the older forms, where the economy of heat is of more importance, it is customary, and good practice to use for the inside layer of the wall a material which is chosen for its refractory quality, and for the outer layer one chosen for its heat insulating properties. Sometimes it may even be well to use a layer of ordinary material between. Fire brick is a good refractory material, but is a fairly good conductor and insulator, while infusorial earth is a poor conductor, but loses that property at high temperatures.

The usual simple formula for the conduction of heat through walls, or that of flow of heat through a conductor in which the heat travels transversely through a number of different materials in series, because it represents the reciprocal of the sum of a number of resistances in series, and because the temperatures at their junctions are not known, it does not lend itself to heat calculations, and the various books and tables which contain it, or the formulæ which are made up from it, do not present ordinarily the information or process of calculation required under the term "estimating."

The usual and well known formula for considering the heat conducted by a body, is as follows:

$$H = \frac{As}{l}(t - t') \qquad (1)$$

in which s is the conductivity of the body in question, l its length or thickness, $t - t'$ the difference in temperature in Centigrade degrees between the faces and A the area of the conductor, and H the heat conductivity stated in terms of gram calories, small centimeters and Centigrade degrees, that is, H in gram calories per second. Or if l is the length in square inches, t in Fahrenheit degrees and k in thermal units (British), Fahrenheit units, then H is in thermal units per second.

In this formula the conductivity s is assumed to be constant throughout the whole conductor, but is not always the case, particularly at great ranges of temperatures, hence either the larger value or a fair mean for the average temperature must be used. The formula also assumes that there is no loss of heat from the other sides of the body, or, if there are walls, that all the heat which enters on one side, leaves on the opposite side only. This is the case with all walls which surround furnaces, but not with rods whose sides are exposed to the air, when heated at one end and cooled at the other. The formula also assumes that the temperatures are those of the two surfaces of the walls, which temperatures are usually given or assumed, when the inside contains a liquid and the outside is water-jacketed, there will probably be no material error in assuming the temperatures of the wall surfaces to be those of the respective liquids, but when the bearing and cooling bodies are gases there may be important differences of temperatures between them and the walls, the present article deals only with the conduction of the walls themselves, and not with this contact resistance.

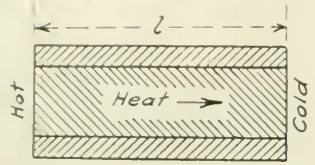
In the above formula the quantity s/l is the part called the conductance, which may be represented by C. Just as in accordance with Ohm's law, the electrical conductance multiplied by the difference of potential in volts gives the current in amperes, the heat conductance C multiplied by the difference of temperature gives the flow of heat per second, H. This conductance C must, therefore, be clearly distinguished from the flow of heat H. C is a constant for any particular case, depending on the size, shape and quality of the material, H the flow is a variable depending on the temperatures. When C is known it is readily calculated from it.

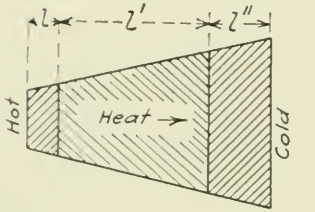
When in a conductor composed of several materials connected in series or parallel, the dimensions and temperatures of the materials, when at steady rate, are known, the heat conductance of the whole can be found by a method of Ohm's law. Imagine the heat flowing through the conducting parts in parallel lines, then any one of these lines can be considered as a single conductor, and the same law applies to it as to the whole. Hence, by finding the heat conductance of the different parts of the conductor, and then combining them in accordance with Ohm's law, the heat conductance of the whole is found. The formulæ for the combination of the different conductances are the same as those for combining resistances. The formula for the combination of the whole becomes very

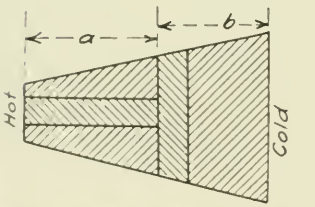
[illegible] different the formula [illegible]

$$C = \frac{k}{l} \qquad (4)$$

[illegible] furnace walls, the differ[illegible] layers perpendicular to the path of the [illegible] Fig. 2, that is, when the heat flows transversely through them in series, the formula for the conductance be[illegible]







FIGS. 1, 2 AND 3.—COMPOSITE FURNACE WALLS.

[illegible] awkward. In such cases, a formula analogous to that [illegible] electricity is the more convenient. In the latter the reciprocal of the conductance is used and is called resistance, while the reciprocal of the conductivity or specific conductance is called the resistivity or specific resistance. Such quantities are not common in heat calculations, and, unfortunately, have no names, and no units, but there is no reason why analogous [illegible] should not be used, and many reasons why they should. It is certainly correct to use them. They are very useful, may often simplify the calculations and they afford a simple means for calculating the temperatures at the junctions of [illegible]

[illegible] analogy between thermal and electrical conduct[illegible] may lead to grave errors [illegible] must be remembered that it is not an ide[illegible] and has some important differences. Ohm's law gives [illegible] which will flow through [illegible] the analogous heat law [illegible] of calories per second, which will [illegible] difference of tem[illegible] the same units, the temperature [illegible] the voltage in [illegible]

[illegible] Ohm's law and the heat law, it must [illegible] that the latter called the heat conductance in the [illegible] the part that is used and that the heat con[illegible] ductivity is the factor k. It will then be correct to consider the reciprocal of the former, namely, $l\,sk$, which may be represented by R, to be the thermal resistance; and the reciprocal of the conductivity, namely, $1\,k$, represented by r, to be the thermal resistivity. It will then be correct to express the analogue to Ohm's law in the form

$$H = \frac{t}{R} \qquad (5)$$

More usually this is stated in the other form

$$H = Ct \qquad (6)$$

in which C is the thermal conductance, for which there is unfortunately no named unit.

Like with electricity, the following formulas apply:

$$R = \frac{1}{C} \qquad (7)$$

$$r = \frac{1}{k} \qquad (8)$$

$$C = \frac{sk}{l} \qquad (9)$$

$$R = \frac{lr}{s} \quad \text{or} \quad \frac{l}{sk} \qquad (10)$$

In this connection it may not be out of place to call attention to the distinctive electrical terms used, and to urge that the same be used in thermal nomenclature also. It has reference to the terminations *-ance* and *-ivity*. Resistance and conductance, which are the reciprocals of each other, refer to a particular piece of material of given dimensions and substance; they are analogous to the weight of a given body; thus, the electrical resistance of a particular rod is so-and-so many ohms, or the thermal resistance is so-and-so many thermal resistance units, which, unfortunately, have no name. Resistivity and conductivity, which are also reciprocals of each other, refer to a property of a material, regardless of its size or shape; they are analogous to the density of materials; they are physical constants for specified material and as such are given in tables of constants. Thus the resistivity of copper is a certain constant, differing from that of iron. They were formerly called specific resistance and specific conductance. It is, therefore, incorrect and tautological to speak of the specific conductivity or specific resistivity.

Referring to Fig. 2, which represents the case in which the resistance formulas are the more convenient, namely, when the heat passes successively through transverse layers of different materials, let s, s', s'', etc., represent the cross-sections in square centimeters, of the successive parts, perpendicular to the path of the heat; l, l', l'', etc., their respective lengths in centimeters in the direction of the flow of heat; r, r', r'', etc., the respective thermal resistivities of the different materials, and equal, respectively, to the reciprocals of the conductivities k, k', k'', etc.; then, like in electrical calculations, the formula for the total thermal resistance from one end to the other, is simply the sum of the individual resistances, namely,

$$R = \frac{lr}{s} + \frac{l'r'}{s'} + \frac{l''r''}{s''} \qquad (11)$$

The loss of heat through this resistance is then determined from formula (5).

As the tables of physical constants usually give the conductivities instead of the resistivities, this formula (11) is more convenient in the following form:

$$R = \frac{l}{sk} + \frac{l'}{s'k'} + \frac{l''}{s''k''} \qquad (12)$$

If the cross-sections are the same for all, as, for instance, for a thin slab, formula (11) becomes

$$R = (lr + l'r' + l''r'') \div s \qquad (13)$$

and (12) becomes

$$R = \left(\frac{l}{k} + \frac{l'}{k'} + \frac{l''}{k''}\right) \div s \qquad (14)$$

Such thermal resistances can, of course, be compared with each other, reduced to percentages of each other, etc., just like any other physical quantities, and it is generally not necessary to reduce them to the heat loss in calories per second, until this particular quantity is desired. If for a certain furnace and certain differences of temperature, a specified heat loss is allowed, then it is best to calculate once for all from formula (5) what the corresponding thermal resistance will be; all the sometimes very numerous trial calculations, for different materials, shapes and thicknesses, can then be made in terms of the resistances by means of the above simple formulas, just as is done in electrical calculations, instead of reducing each one of these calculations to heat losses.

Another case in which the use of thermal resistances instead of conductances simplifies calculations is the case shown in Fig. 3, in which there is a combination of layers, some of which are parallel to the path and others perpendicular to it. In such a case the calculation of the part *a* is first made in terms of the joint conductance of its parts, by means of formulas (2), (3) or (4). This total conductance is then reduced to resistance by taking its reciprocal (7) and the part *a* as a whole may then be considered as another transverse layer like those in the part *b*; its resistance thus obtained must then be added to the resistances of the parts *b* by means of formulas (11), (12), (13) or (14). In this it is, of course, assumed that the temperature is uniform all over the junction of the parts *a* and *b*.

The formulas in terms of resistances also enable one to determine the temperature at the junction of any two layers of Fig. 2. This may at times be important and give unexpected results. For instance, if the inside layer of a high temperature furnace is firebrick, which does not insulate well at high temperatures, and the outside is infusorial earth, which loses its good insulating quality when highly heated, it may be important to determine the actual temperature at their junction, in order to find out whether the actual ranges of temperatures between the junction and the two end surfaces correspond with those assumed in selecting the proper conductivity from the tables. Also to see whether the temperatures of the cooler layers exceed the limit which they can stand, as, for instance, with felt or glass-wool. The temperature of the junction will probably be found to be higher than was expected.

Just as the voltage in an electrical circuit falls in proportion to the electrical resistance, so the temperature at the junctions of the transverse layers in Fig. 2 will fall proportionately to the thermal resistances. For instance, let T, T', T'' be the falls of temperature in the three successive layers in Fig. 2, and $T + T' + T'' = t$, then the fall through the first layer will be, from formula (12),

$$\frac{T}{t} = \frac{l}{sk} \div \frac{1}{K}$$

or

$$T = \frac{tl}{Rsk} \qquad (15)$$

or from (5) and (10)

$$T = HR_1 \qquad (16)$$

in which R_1 is the resistance of the layer.

Through the second layer the temperature drop will be

$$T' = \frac{tl'}{R_2 s'k'} \text{ or } HR_2$$

and so on.

The above formulas are all numerically correct if the quantities are in terms of the units stated above, namely the Centigrade, the centimeter, gram calorie and Centigrade degree. If, however, the units are the more square inch, thermal unit, (pound Fahrenheit unit) Fahrenheit degree, and the conductivity or resistivity is in the thermal unit, square inch unit, then these formulas will also be correct and the loss of heat will be in thermal units per second. Any other combination of units may be used provided it is done consistently throughout, special care being taken with the values of k and r (see below). In this country it may often be most convenient to use the inch and the calorie, and, therefore, the Centigrade degree, while the conductivity k most generally found in the best tables is in the calorie, cubic centimeter unit, also called absolute or c.g.s. units. With this mixed or hybrid system of units formulas (1) to (6) and (9) will be correct if the right-hand side be multiplied by 2.54, and (10) to (16) if multiplied by 0.3937 (approximately 0.4). Formulas (7) and (8) are, of course, the same in any system of units.

The conductivities or specific conductances k as found in the best tables are usually stated in terms of the gram calories per second, the cubic centimeter and the Centigrade degree, they are then said to be given in absolute or c.g.s. units. To reduce these constants to cubic inch units, but still retaining the gram calorie and the Centigrade degree, multiply this conductivity k by 2.540 (or approximately by 10/4). Thus for firebrick this constant is given in tables as 0.0014, meaning that so many gram calories will flow per second between the two sides of a centimeter cube, for 1° C. difference of temperature. When this is multiplied by 2.540, giving 0.00356, it is in cubic inch units, gram calories per second and Centigrade degrees. To reduce the original constant 0.0014 to thermal units, inches and Fahrenheit degrees, multiply it by 0.00560, thus giving 0.000,007.83 for firebrick.

To reduce gram calories per second to watts, multiply by 4.186; to reduce them to thermal units multiply by 0.003,968. To reduce thermal units per second to watts multiply by 1054.9.[1]

The following numerical examples will illustrate the use of the formulas:

An electrode of soft steel, 4 in. square (cross section, 16 sq. in.), passes through the wall of a furnace 12 in. thick and is surrounded on all sides (but not on the ends) with 4.5 in. of firebrick (cross section $(4.5 + 4. + 4.5)^2 - 16 = 153$ sq. in.). The temperature of the hot end is 500° C. and of the cold end 20° C. How much heat will flow through both together? This case is illustrated in Fig. 1; both conduct in parallel. According to Richards[2] the heat conductivity of such iron is 0.11 and of firebrick 0.0014 in gram calories, centimeter and Centigrade units. Formula (2) is the one to use, as this is a case of two conductances in parallel. But the conductivities are stated in cubic centimeter units, hence they must both first be multiplied by 2.54, or better, the whole right-hand side must be multiplied by that factor. Hence the joint conductance is

$$C = \frac{(16 \times 0.11) + (153 \times 0.0014)}{12} \times 2.54 = 0.403 \text{ conductance units,}$$

hence, according to formula (6), the heat loss is

$$H = 0.403 \times 480 = 193 \text{ gram calories per second.}$$

The two quantities in the numerator of the former, namely, 1.76 and 0.214, also show the relative losses of heat through the two parts, as they will be in proportion to the conductances. Hence about eight times as much goes through the steel as through the firebrick.

Referring to Fig. 2, let the linings of a furnace consist of a 4 in. layer of firebrick on the inside, then a 5 in. layer of infusorial earth, covered with 3 in. of felt on the outside. The temperature of the inside surface is 1300° C. and of the outside surface 50° C. The inside dimensions are 12 in. cube. What is the total heat loss, and what will be the maximum temperature of the infusorial earth and of the felt? This is a case of conducting layers in series. Hence the resistance formulas are the simpler to use. As the lengths, cross-sections and conductivities are all different, formula (12) is the best one to use when the constants taken from the tables are conductivities or (11) if they are resistivities. The conductivities taken from Richards, cited above, are for firebrick from 0.1360, 0.0931, for infu-

[1] To be reduced to thermal units. Compare Table [illegible]
[2] Trans. Amer. Electrochem. Soc., Vol. [illegible]

Some Fundamental Considerations on Coal.

By W. Jones.
Chemist for the Metropolitan Street Railway System, of New York.

While it is surprising, it is none the less true, that of all supplies purchased by a manufacturing concern the one that receives the least attention, and in the majority of cases is wasted, more than all others, is coal.

It is so very easy to make a fire and obtain heat that people seem to think that if they only get the heat they want that is all that is necessary. They do not for a moment stop to think of the cost of the heat, nor do they consider what amount of heat is utilized, and what amount is wasted. To be sure, large steam plants are beginning to take up this matter, but in most cases it is only in a half-hearted way.

In using coal we find many points to be considered, not only the proper combustion of the coal, but what is just as important, the use of the coal that is best suited to the work to be performed.

This naturally brings us to the purchase of the coal to start with. It is of no use to say that a certain grade of coal is the best for a certain purpose, or that a coal having 15,000 B.t.u. is better for us to use than one having only 14,000 B.t.u. Of course, we all understand that the more heat in a coal, the better in general, other things being equal, but when we take into consideration the use it is to be put to and the kind of furnace we are to use, this is not necessarily the case and the lower grade may be the better for our purpose.

Again, we cannot all have the highest grade of coal, and it is necessary that we use the coal that the market affords, or that which is produced in that part of the country where we wish to use it, so that in many cases it is not optional with us what coal we shall use, but rather how to make the best use of what we can get.

The manager of a plant generally gets what he considers the cheapest coal he can buy. By this I do not mean the poorest coal, but what he considers the best for the price. He usually does not give the slightest attention to the composition of the coal or its heating value, and if there is no choice of coal, he still less thinks about building his furnaces so as to get the best results from what coal he can get.

We will consider, for instance, the use of coal for raising steam. Let us suppose a furnace of such dimensions as to burn with good results a coal having 6 per cent ash, 16 per cent volatile matter, and 78 per cent fixed carbon. This is what would be considered a first-class steam coal, and in the furnace used, it gives fine results.

Now let us go to the West where such a coal cannot be had, but in its place we get coal of the following analysis: ash, 15 per cent; volatile matter, 30 per cent; fixed carbon, 55 per cent. It stands to reason that such a coal would not give us the same results in proportion to its contained heat, if we burn it in the same furnace.

We would be likely to produce too much smoke, and the combustion would not be perfect; or, if it was, the zone of combustion, where the heat is most intense, would be so far removed from where we want it that the heat would be largely lost in the flue. But with a knowledge of the composition of the coal, a furnace could be constructed that would give us results equal to the other.

Again, when we come to metallurgical work in a reverberatory furnace, we need a coal that will give a more or less long flame. This means a certain amount of volatile matter, and the amount of volatile matter in the coal would determine the best shape and construction of the furnaces. I have known cases where a coal which gave the best of results in a large reverbera ory, was used to raise steam, with the result that steam could not be kept up; but when a coal of a much lower grade, which could be had for about one-half the cost, and which did not contain so much volatile matter, was used, there was no

trouble. Simply, on account of its construction, the furnace was not fit for the combustion of the higher grade coal, or, if the furnace had to be used as it stood, a lower grade of coal had to be used.

In determining then what coal to buy or how to build the furnace to suit the coal to be had, it is necessary to have the proximate analysis of the coal.

On the other hand, to determine what efficiency we are getting, it is necessary to have the B.T.U. or heating value of the coal.

These analyses should be made on all coal as received, so that we may know that we are getting the coal and heat we are paying for.

For determining the heating value of coal, we find many forms of calorimeters on the market, but unfortunately the cheaper ones, which are largely used, are of little value, as the results they give are not only not constant, but are generally much too low. The same coal in such an instrument will vary as much as 5 per cent. The correct determination of the heating value of a coal can best be made in the bomb calorimeter, such as Mahler's or some modification of it, in the hands of a careful man. Tests of this kind require, of course, experience and carefulness.

It would, therefore, seem to be wisdom on the part of any manager to buy his coal on analysis and heating value, and then to use it in such a way as to get the best results from it: that is, to see that his heat goes to making steam and not passing into the flue.

This, then, brings us to the combustion of the coal, so as to get the desired results. To get these, it is not only necessary to build the furnace to suit the coal, but we also have to regulate the thickness of the fire bed and the amount of air, so that the proper combustion takes place and the heat is produced where we want it, without using an excess of air, which, of course, only cools the fire.

After we have got our furnace built and running, we should watch the flue, as all heat entering there, of course, does not make steam, but is lost.

We should make frequent analyses of the gases entering the flue, and in the case of soft coal we should get about 14 to 15 per cent CO_2.

The percentage of the carbon dioxide gas is a very good guide as to the amount of excess of air that is being used in proportion to the coal burned. It is, however, not only necessary to have a high percentage of CO_2, but it is also necessary to maintain a low temperature in the flue as any fireman can get a high-percentage gas, with a high flue temperature, and at the same time have a large loss of heat in his flue. Hence, when determining the amount of heat lost in the flue, the temperature in the flue should be determined by means of a thermometer when taking the gas sample. Then by using the following formula we can find approximately the loss of heat. The heat loss in per cents $= \frac{T - t}{C} \times 0.30$. Here T is the temperature of the flue in degrees Fahrenheit and t the temperature of the air entering the grates. C is the percentage of CO_2 in the gas.

This loss should not be over 17 per cent. and when economizers are used, should be still less.

By testing the gas at the intake of the economizer and again at the outlet, we get very closely the saving of heat in the economizer.

It is frequently the case that where economizers are used a much larger amount of heat is allowed to enter the flue and go to the economizer to be absorbed than is saved. I know of cases where gases entering the economizer showed a loss of heat of 30.3 per cent and 32.2 per cent, and after passing the economizer they showed only 14.3 per cent and 16.6 per cent, so that the economizer produced a saving of 15.4 and 15.6 per cent. respectively.

A New Polishing Machine for Metallographic Work.

By J. W. Ver...

In metallography, the proper polishing of the specimens to be examined is a most important detail. One of the very best methods is hand rubbing upon polishing mediums of varying degrees of fineness, mounted upon wooden blocks. While this method has the advantages of simplicity and flexibility, it has the great disadvantage of being very laborious, and has consequently been almost superseded by mechanically driven polishing machines.

With these machines the time factor has been placed upon a satisfactory basis, but there is still plenty of room for improvement in other details. For example, there is a lack of flexibility. One is limited to, say, four different surfaces for polishing, which is only sufficient for material of one character, and does not give the necessary range where the specimens may vary in nature from the softest brass to the hardest steel, since polishing powders suited to one material are not satisfactory for another. Where the disks are changed, it is usually done only with considerable trouble. Another most serious objection is that where one machine is used by a number of persons, as in a students' laboratory, there will always be the condition of the careful worker being compelled to rectify, or to suffer from, the results of another's carelessness in getting rough powders on fine disks, or tearing polishing cloths, etc.

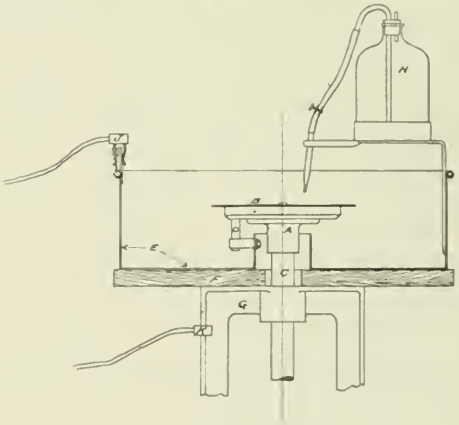


FIG. 1

VERTICAL SECTION OF APPARATUS.

To eliminate some of these undesirable features of polishing apparatus, there has been devised at the metallographic laboratory in the Chemical Engineering Department of the University of Wisconsin, a machine which has proven so superior to the common type that it has been thought advisable to present a description of it as being perhaps a matter of interest to others engaged in metallographic work.

Fig. 1 shows a vertical section of the apparatus. As will be seen, it is of the vertical spindle type, with rotation of the polishing surface in a horizontal plane, which is conducive to better results than where the disks are vertical. The distinguishing feature is the magnetic clutch A, which holds down the polishing disk B, and which is illustrated in detail in Fig. 2. The clutch, which is 6½ in. in external diameter, consists of two cast iron parts, T and S, electrically insulated from each other by hard rubber, as shown. H is the magnetizing winding, one terminal being connected to S at J, the other to T at Z. Y is a plate of non-magnetic material, such as aluminum or brass. Thus, when current is sent through the magnetizing coil, the

[illegible] the sheet-iron polishing [illegible] tightly to the clutch surface

Referring again to Fig. 1, the part *S* of the clutch, and consequently one terminal of the magnetizing coil, is in electrical connection with one terminal of a storage battery through the spindle *C*, [illegible] *D*, and connecting cable and clip *K*. Part *T* of the clutch, with the other terminal of the magnetizing coil, connects with the other pole of the battery through the contact brush *D*, the galvanized iron drip pan *F*, and the cable and

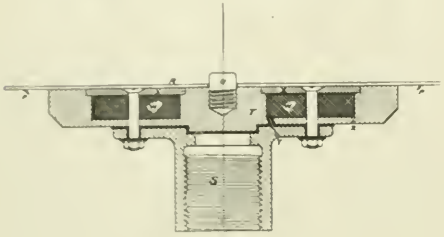


FIG. 2

MAGNETIC CLUTCH.

clip *J*, *J* and *L* being at the same time used as a switch to make and break the magnetizing circuit. The wood base *F* insulates the pan *E* from the frame *G*.

The polishing disks are of sheet iron, about No. 18 gage, and 8 in. in diameter. At twelve points near the circumference, V-shaped cuts are made, and the points bent down and sharpened (as shown at *P*, Figs. 2 and 3), thus forming fasteners upon which to hook the polishing cloth.

In the operation of polishing, the spindle is set in rotation and the desired disk slipped over the centering pin *U* (Fig. 2)

FIG. 3

PART OF POLISHING DISK.

and gripped by closing the circuit at *J* — *L*. Water for wet polishing is obtained from the bottle *H* (Fig. 1) and the flow regulated by a pinch cock. In changing disks, it is only necessary to open the circuit at *J* — *L*, remove the disk *B*, and substitute a new one without stopping the machine. The energy for magnetizing is very little, a current of 1.3 amperes from a 6-volt storage battery being sufficient.

In conclusion, the advantages of this apparatus may be summarized as follows:

1. The rotation in a horizontal plane (although the principle could be applied to vertical rotation as well).

2. The ease of manipulation in changing polishing mediums.

3. The flexibility, since an endless variety of surfaces, such as linen, broadcloth, felt, chamois, leather, parchment, etc., can be easily prepared and treated with any desired polishing powder. Or the surface of the disk could be lead plated, or otherwise treated for special purposes.

4. Worn out cloths can be easily changed, since no complicated fastenings are required.

5. Each operator can have his own set of disks, since they are very easily and cheaply made. In the case of students, this fixes the responsibility for the quality of each man's work.

6. Because of the little space occupied, disks can be set vertically in small portable racks, so that while in use they can be at the hand of the operator, and when not in use they can be put away in dust-proof cupboards.

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Smelting of Iron Ore in the Electric Furnace, in Comparison with Blast Furnace Practice.

By Joh. Härdén.

The problem of electric smelting of iron ore without the use of a blast furnace has been so often alluded to of late that a critical discussion of the subject, and comparison with blast-furnace practice, seems justified.

The matter has been the subject of a number of articles in various technical papers. References will be found at the end of this article.

It may be advisable to first consider the expenditure of coal for heat and reduction in the blast furnace, so as to obtain figures for comparison. The theoretical figures are partly taken from H. Jüptner's "Siderologie," Part III (which may be regarded as a reliable authority), and are partly obtained by direct calculation.

The practical figures are obtained from blast furnace plants in practical operation, and from a production extending over several years. The furnace in question is operated with charcoal, but the thermal effect does not differ much from that of a coke furnace.

As regards the electric furnace, the figures for these are obtained from the report of the Canadian commission (E. Haanel), from A. Stansfield's and W. A. Borcher's books on electric furnaces, as well as from the author's own observations.

Reduction of Iron Ore in the Blast Furnace.

For the reduction of 1000 kg (1 metric ton) of pig iron (not including the necessary heating) we require:

From	Fe O (Protoxide)	214.3 kg	carbon.
	Fe_3O_4 (Magnetite)	285.7 "	"
	Fe_2O_3 (Hematite)	321.4 "	"

Assuming all carbon oxidized to CO only.

These reactions, however, also require an elevated temperature, and the necessary heat has to be derived from coal or from electric energy.

Now it is true that the reaction is practically not heat-consuming if the carbon is supplied in the form of CO instead of as free carbon (coal, coke or charcoal). But, as is well known, it is necessary, for practical reasons, to supply the carbon in the free state and try to arrange the operation so that as much as possible of the iron is reduced by means of the CO developed. It will be seen that this is of special importance in the case of electric smelting. How far this result is obtained in blast-furnace practically will also be shown.

The energy required for the *reduction* of the iron ore only, per metric ton of pig iron, is from:

Fe O	832,000 kg calories.	
Fe_3O_4	943,000 " "	
Fe_2O_3	1,058,000 " "	forming CO from C.

For the present it will be quite sufficient to confine ourselves to the smelting of Fe_2O_3 (hematite), as this class of ore has proved most suitable for treatment in the electric furnace, being easily obtained in the form of briquettes. As the theoretical figures for the other classes of ore are given above, they may be easily applied to the calculations for electric smelting.

We may assume that the fuel in question (wood charcoal, for

reasons given below) has a calorific effect of 7500 and contains 80 per cent carbon, which is a fair average

Owing to the reverse oxidizing action of CO_2 on iron, in actual practice only, at most, one-third of the carbon can be converted to dioxide. On this assumption, the carbon necessary for the chemical reaction of reducing 1 ton of iron from hematite is 241.1 kg of carbon, or 301.0 kg of 80 per cent charcoal.[1]

On the same assumption, the energy required is:

For the reaction	732,000 Calories.
For the melting of the iron	310,000 "
For the melting of slag	72,000 "
Total	1,114,000 Calories.

Now, again, on the same assumption, the calorific effect of the fuel when burnt to $CO_2 \times 2\,CO$ is about $3250 = (\frac{1}{3} \times 0.3 + \frac{1}{3} \times 0.7)$, but each kg of charcoal burnt for this purpose (again on the same assumption) requires $\frac{64}{36} \times \frac{100}{23} \times$ kg of air, and this is heated to about 800° C. by a portion of the waste gases. There are thus reintroduced into the furnace with the blast $\frac{64}{36} \times \frac{100}{23} \times 800 \times 0.24$ calories $= 1480$ calories per kg of fuel burnt, which raises the *effective* calorific power of the fuel to $3250 + 1486 = 4696$ calories. Therefore, the amount of fuel required for heating purposes will be

$$\frac{1114000}{4696} = 237 \text{ kg.}$$

We have already stated that the reduction only would require 321.4 kg carbon; assuming that the charcoal contains 80 per cent free carbon, we would have to spend $321.4 \times \frac{100}{80} = 404$ kg charcoal, for reduction, and 237 kg for heating, but, for the reasons given above, we are able, by properly regulating the operation, to reduce the total expenditure to 538 kg of charcoal for each ton of pig iron produced.

If we compare this figure with those actually obtained we find:

At the Herrang Works, in Sweden, where chiefly hematite briquettes are smelted by means of charcoal, the average consumption taken over a period of three years was 570 kg per ton of pig iron produced.

This may be considered as a very favorable figure; as the blast furnace is by no means giving 94 per cent efficiency, we must assume that the operation was so regulated that an even larger quantity of iron was reduced by means of the CO formed than assumed above.

The average price paid at these works for charcoal delivered from a kiln was $12 per ton. Thus, the cost of fuel per ton of pig iron would be $6.84, of which $4.84 is paid for the reduction and the remaining $2 for the heating.

We will now compare this with **electric smelting.**

We will assume that the ore again consists of hematite briquettes, because in this form it is more convenient to charge, and will not strain the lining as much as magnetite, besides being more readily obtainable. Should the latter be used, however, the comparison will be sufficiently accurate, for although the Fe_3O_4 will need only 285.7 kg of fuel per ton of reduced iron, the heat consumption is also less than with hematite, or 943,000 calories, against 1,058,000, so that the proportion will be nearly the same.

We need here, as for the reduction of 1 ton of pig, 404 kg coal, costing, say, $4.84.

The design of the furnace will present certain difficulties in arranging the operation so that the bulk of the iron is reduced by means of CO, owing to the difficulty of producing a shaft, as in the blast furnace, for this would interfere with the application of the source of heat, as will be shown later. Assuming, however, that it is possible to reduce, say, 50 per cent of the iron by means of CO (which is probably not an underestimate), we need for the reduction only 529,000 calories. Furthermore, we need for the heating of the iron and the slag another 382,000 calories, as before, or altogether 911,000 calories. If we assume that the thermal effect of the electric furnace is 60 per cent (which has really been obtained in practice), we find that we have to spend 1,518,300 calories. As one kw-hour is equal to 860 calories, we will thus have to spend 1768 kw-hours.

This corresponds well with the results reported by the Canadian commission (page 108 of their report) from Livet, where an average of 0.3 hp-year per ton was consumed. This will give in round figures 2000 kw-hours per ton. It also corresponds with the results obtained in a Héroult furnace, and reported by Dr Neumann (Elektrometallurgie des Eisens, page 169), where it is stated that the reduction of 1 ton of pig iron from hematite requires 1705 kw-hours (1732 to 1989 for magnetite).

If we assume that the cost of power is $20 per kw year (which is a fair average) or 0.226 cent per kw-hour, we find that the energy per ton of pig will cost $3.90.

In the case of electrode furnaces we have also to add the cost of the carbon electrodes, the consumption of which is rather high when smelting from ore. Dr. Neumann states (Elektromet. d. Eisens, page 170) that the consumption was 8.1 kg per ton of pig. The author's observations give a consumption of 15 kg for *steel smelting*, and it is certainly not less for ore smelting; if we assume 20 kg we will probably be closer to the mark, remembering that a large portion of the electrode has to be removed and repressed (nearly 40 per cent). If we take the price of electrodes to be, say, $0.05 per kg, we have an additional cost of $1 per ton of produced pig iron, or the sum of $4.90 for energy and electrodes alone.

We are now able to compare the two methods, viz., **blast-furnace versus electric smelting.**

Taking the conditions to be equal in both cases, as to the class of ore, amount of labor (for either a blast furnace or an electric furnace of the same yearly output, five men per shift should be required), and class of fuel available, we find on comparison that we need in either case for the reduction alone about 400 kg carbon, at a cost of, say, $4.80 per ton of iron.

In the blast furnace we have to spend another 170 kg at a cost of, say, $2.04, or a total of $6.84 per ton produced iron.

In the electric smelting furnace an expenditure of $4.80 for the reduction, $3.90 for power, and $1 for electrodes is necessary, making a total of $9.70, or *$2.86 more per ton of produced iron.*

Another important feature in blast-furnace practice is the considerable gain in the form of blast-furnace gas, which can be utilized to drive gas engines, apart from preheating the air. It is nowhere stated that such a utilization of the gas has been accomplished in the case of electric smelting, although we will not deny that it could be done.

Juptner states (Siderologie, pages 231 240) as follows:

"One ton of charcoal, used in the blast furnace, would yield theoretically 5,200,000 calories on combustion." Others, such as Witz and Hubert,[2] state 4,320,000, and Lurmann[3] gives 4,200,000 calories. If we say that the average is 4,300,000 calories we may be nearer the mark.

Lürmann (loc cit.) states that of this 10 per cent is lost and 31 per cent is used for heating the blast, leaving 59 per cent, while Junge[4] says that 55 per cent is available.

We may take 57 per cent as a medium figure. This gives us $0.57 \times 4,300,000 = 2,450,000$ calories in useful gas per ton of coal spent.

As before stated, for obtaining 1 ton of iron, 570 kg of coal is needed; thus, applying the above figures, we may recover 1,396,500 calories.

[1] A charcoal of 7500 calories should contain nearly 90 per cent carbon, thus giving 267 kg as necessary for the reduction

[2] Ann. d. Mines de Belg.
[3] Stahl und Eisen 99, 483
[4] Iron Trade Review

economical way of utilizing [illegible] Hubert states that [illegible] and this seems to be [illegible] 4,450 calories. If we deduct from this the [illegible] of the furnace, which [illegible] per cent of the total calorific value [illegible] figures show that 91,000 [illegible] necessary. Taking the mean of these figures, or [illegible] we are able to recover 280,000 calories, or about [illegible] per ton of iron produced.

We must here note that the price of electric energy was about [illegible] per kw-hour, consequently, we recover $0.738, or the [illegible] in fuel per ton of produced iron will be $0.84—[illegible] $1.11, against $0.70 in the electric furnace.

It is, of course, possible that the latter may be so developed that a portion of the gas may be recovered here also, especially as no heating of the blast is necessary. This, however, seems to be a matter of considerable difficulty and has not been [illegible] as far as is known to the author.

Now, a word about the furnace itself. Although there is a great deal of literature on the subject (see list at the end) no writer seems to have discussed the practical side of the matter in earnest, but most have confined themselves to statements as to power consumption, character of the iron produced and, in some cases, the cost of power and labor, etc.

There are, however, practical points to be considered. It is not our intention to enter into a criticism of any furnace in particular, its advantages and disadvantages, as this is quite outside the scope of our discussion. We will only compare the various classes of furnaces proposed for the purpose with the blast furnace. Of course, the latter has been in use for ages, and has undergone a series of improvements, while the electric furnace is a child of to-day and will undoubtedly be perfected in time.

(1) **The Electrode Furnace.**

Of this we have types in which (a) the arc is struck between carbons above the charge proper, the heat being thrown down directly and from a reflecting dome; (b) where the arc is struck between one electrode (or more in parallel) and the charge, the bottom forming the other terminal; (c) where two or more arcs play between two or more electrodes and the charge in series.

One of the great disadvantages in all electrode furnaces is that the carbons are very rapidly consumed owing to the reaction going on in the furnace, and as the electrode manufacture is both costly and difficult, this matter is of the greatest importance. In those of type (a) the consumption is somewhat less, as the arcs and the carbons are placed above the charge, but the electrodes are also generally small in diameter, but they are easily broken off and destroyed by charging. Further, this arrangement is seemingly very ineffective, as all the heat has to come from *above* the charge. We must, however, as has been shown, arrange the operation so that most of the carbon is converted into CO which passes upwards through the charge and reduces the ore, in order to decrease the cost of fuel. If the source of heat is placed above, this cannot be the case, and the efficiency is thus lowered.

This may, to a certain extent, be obviated in type (b), where the charge acts as an intermediate resistance, but here again [illegible] the largest portion of the electrode, is surrounded by the charge in the hottest zone of the furnace and is, therefore, very rapidly consumed. Besides, if the bottom is to act as a second electrode, it is always in danger of being eaten through and allowing the iron to escape: in the case of a water-cooled bottom electrode this feature is doubly dangerous, for every foundryman knows what violent explosions take place if molten iron is brought into contact with water.

This is avoided in type (c) with two or more electrodes from above, in series; but here again the great consumption of electrodes is a very weighty matter, more especially as a furnace, to compete with a blast furnace, must have very heavy electrodes, up to 24 x 24 inches in section, by 5 to 6 ft. in length. Such carbon blocks are very costly and difficult to manage.

Now, one might suggest, as has indeed been already suggested, "why not place the carbons through the wall of the furnace"? This is all very well in theory, but will not work well in practice. First of all a good portion of the electrode is still brought into the hottest zone of the furnace, and exposed to the burning gases, which will attack them all the quicker because of the high temperature; secondly, almost all refractory material has the annoying property of becoming a good conductor at high temperature, and the current will therefore soon begin to flow through the furnace walls and rapidly destroy them. A water-jacket is again heat-wasting and highly dangerous.

For this reason experienced furnace designers have long ago realized that the electrodes must "burn free," i. e., must nowhere touch the furnace wall. Then again, the question of a suitable holder becomes a great difficulty and a source of endless trouble. Also, the proper regulation of the electrode is very difficult, surrounded as it is by the packing charge, not to speak of the possibilities (or impossibilities) of recovering the escaping gases.

One furnace has been proposed and tried, where the molten iron itself was collected in two grooves or hearths, each connected with one terminal, thus striking an arc or forming a resistance bridge by means of the charge. The two grooves were separated by means of a non-conducting partition, but soon after heating up this began to conduct, whereby the current simply took the shortest path and rapidly destroyed the partition, causing short-circuiting and leakage.

(2) The plain **induction furnace** as a smelting furnace.

This class of furnace has also been tried for the purpose, but owing to its nature, the circular hearth with a vital part, the primary coil, in the center, its application seems more than problematical. Besides, the source of the heat, although rightly placed at the bottom of the furnace, is in the molten iron itself, which thus has to be raised to a very high temperature, and it will be extremely difficult, if not impossible, to find a suitable lining to stand the strain.

(3) The **combined induction and resistance furnace.** (Rochling-Rodenhauser.)

This furnace may, at a first glance, seem to overcome some of the above difficulties, owing to the principal, large rectangular hearth in the middle, between the two energizing coils; but here again, the heat must only be generated in the bath of molten iron, with all the disadvantages of such a practice, and besides, we must remember that the "side plates," acting as secondary conductors, will be strongly attracted by the slag and fluxes necessary, so that in this case, with a strong reaction immediately above the bath (which of course must be of variable depth during the operation), the life of these "side plates" is not likely to be of any great length, although they have proved satisfactory in steel refining.

Finally, in all cases where a large current-density is required in the charge, the heavy conductors necessary form a very important and costly item, more so even in the case of an electric furnace.

It is certainly not our intention in this article to stamp the

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[illegible] Electrochemical and Metallurgical Industry vol. III, pp. 95, 150, 190. The following summary of figures found by different investigators [illegible] available electrical surplus energy per ton of iron; the [illegible] partly due to the greater amounts of coke per ton of [illegible] Greiner (2224) lb. coke per ton of [illegible] 60 kw-hour. Uehling 848 hp-hours = 636 kw-hours; [illegible] kw-hours; Thomson [illegible] for Gayley dry blast [illegible] 543 kw-hours. Mr. Harden's figure, given above, is [illegible] per ton of iron, and it will be [illegible] —Editor.

electric smelting furnace as a hopeless impossibility—far from it; but it is only intended to state things *as they are at the present*, and keep some of those optimists a little nearer the earth who dream that the days of the good old blast furnace are doomed, and must give way to the more modern electric smelting. We certainly believe that the smelting furnace is capable of attaining perfection, like everything new, but all improvements must go steadily forward, not in leaps and bounds, as the effects of undue rashness are only leading us astray.

Now, *where* would it be justifiable to try electric smelting, even in spite of its higher cost? One might say, "If I need 400 kg coal in all cases for reduction alone, and only another 175 kg as fuel for each ton of iron, I might just as well spend these in a blast furnace, and do away with all the trouble of electric smelting!" That is so, but take a place like India, or the Western States of U. S. A., where practically no coke is to be had at the present, but with large deposits of cheap ores and abundant water power, especially if the latter is utilized for other purposes, giving an easy surplus at an extremely low cost per unit, available for electric smelting.

This is the right place for a plant of this kind, for wood and forest waste *may* be had in sufficient quantities to permit, by means of a good charcoal kiln, the production of charcoal for the reduction only, but no more; and this is the reason why we have only taken charcoal into consideration as a fuel. Besides, a well-managed charcoal kiln will give by-products of such value that a good portion of the charcoal is paid for by them, so that even under unfavorable conditions the cost of charcoal should not exceed $12, as stated before.

Dr. Neumann states[1] that charcoal may be used with satisfactory results in the electric smelting furnace, especially if it is in the form of briquettes, either by itself or together with the ore.

In the Lash process[2] we have a good example of such a method of operation. Here, iron ore, turnings, etc. (sweepings), and carbon in some forms, are briquetted and reduced, either in an open-hearth furnace or an electric smelting furnace. Tests are reported to show that this process may, although not cheaper than the blast furnace process, be quite justified and fairly economically worked in such cases where the production is not large enough to justify the erection of a blast furnace, and where a great economy in coal is necessary. In this way electric smelting may be employed as a profitable step toward the final perfection of the art.

LONDON, November, 1908.

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[1] *Elektrometallurgie des Eisens.*

[2] ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, vol. V, pp. 279, 322, 344, 378, 440, 455, 479, and vol. VI, p. 493.

The Electrolytic Reduction of Aluminium as a Laboratory Experiment.

BY M. DE KAY THOMPSON.

It is the object of the following paper to describe the difficulties encountered in attempting to electrolyze a solution of aluminium oxide in melted cryolite according to the Hall patent, and to show how they may be overcome to a certain extent. This experiment was first tried in the full expectation that the results obtained by Haber and Geipert[1] would be easily reproduced, but since, after numerous attempts, this was found to be impossible, it was thought an account of these experiments might be interesting to any who may have encountered the same difficulties.

The sources of electricity used in the following experiments were a 25-kilowatt transformer with variable voltage for melting up the cryolite at the start and a 25-kilowatt double-current generator for the electrolysis. The two windings of the armature of the generator could be connected in series, giving about 25 volts, or in parallel, giving half this voltage, or one winding could be left idle.

The chief difficulty with the experiment may now be described. If, after melting up, cryolite mixed with 20 per cent of its weight of aluminium oxide in an Acheson graphite crucible, the crucible forming one electrode, a graphite rod the other, the direct current is thrown on, at first a large current passes, but very soon drops nearly to zero. Simultaneously there is a peculiar effect at the anode, called hereafter the "anode effect." It seems that where it dips into the melted cryolite a film of gas covers it, insulating it from the cryolite.

This is similar to the effect observed by Wöhler[2] in the electrolysis of melted calcium chloride, with this difference in the case of cryolite, however, that opening and closing the circuit does not in any way eliminate it. The appearance of the molten salt not wetting the anode suggests its similiarity to the "spheroidal state." Of course the presence of gas at the anode is due to the liberation of oxygen from the alumina which combines with the carbon to form carbon monoxide or dioxide. The following experiment is given as an illustration:

EXPERIMENT 1.

Anode.—Acheson graphite rod, 5 cm. diam.

Crucible.—Acheson graphite, 10 cm. inside diameter, 6 cm. depth, walls 1.75 cm. thick. Rests on graphite block, to which copper connections are screwed. The crucible was packed around with carbon held in place by asbestos boards.

Cryolite.—Natural cryolite mixed with 20 per cent of its weight of aluminium.

The cryolite was melted up with the alternating current and the direct thrown on.

[1] *Zeit fur Elektrochemie*, Vol. 8, 1 (1902).

[2] *Zeit. für Elektrochemie*, Vol 11, 616 (1905). This effect is not nearly so troublesome, if the anode surface is increased, as in the apparatus of J. H. Goodwin, *Proc. Am. Phil. Soc.*, Vol. 43, 381 (1904). Here the crucible is anode; a rod in the center is the cathode.

Temperature by a thermoelectric junction in a graphite tube.

Time.	Amperes	Volts	Temp.	Remarks.
3 03	270	12.0	910	
3 05	250	13.0	910	10 g. Al_2O_3 added.
3 06	180	....	.	
3 07	240	12.5	880	
3 12	240	13.5	870	10 g. Al_2O_3 added. Heated up with alternating current.
3 25	390	13.0	. .	
3 29	300	11.8	.	
3 32	. .	....	.	"Anode effect."

This experiment is characteristic of the way the electrolysis acts with this size crucible. From the fact that the alternating current had to be thrown on at one time in order to heat it up, it is evident that the power sent through the cell was not sufficient to keep it up to the necessary temperature. The same result is obtained with artificial cryolite made by mixing aluminium and sodium fluorides. The other experiments with this size crucible will be omitted, as similar results were obtained.

Next a crucible of exactly the dimensions used by Haber and Geipert was turned out of a graphite block. The diameter at the top was 138 mm, at the bottom 113 mm, and the depth, 70 mm. The electrode was 50 mm in diameter, as used previously. Natural cryolite was used, containing initially 10 per cent alumina.

EXPERIMENT 2.

Cryolite melted up and direct current applied.

Time.	Current.	Volts.	Remarks
12 46	300	12.0	
12 50	350	12.4	
12 55	270	...	
1 05	280	11.0	
1 10	280	11.8	
1 15	275	...	
1 20	275	15.0	"Anode effect."

Here fresh cryolite added, melted with the alternating current and direct current applied.

Time.	Current.	Volts.	Remarks.
1 34	400	10.5	
1 37	400	10.5	
1 40	400	. .	10 g. Al_2O_3 added.
1 42	400	11.0	" " "
1 53	400	....	" " "
2 05	180	12.7	" " "

"Anode effect." Here melted cryolite was ladled out and fresh cryolite melted up.

Time.	Current.	Volts.	Remarks.
2 30	400	11.0	
2 32	400	11.4	
2 35	400	11.4	"Anode effect."

Cryolite again removed and fresh put in its place.

Time.	Current.	Volts.	Remarks.
2 58	400	10.6	
3 00	350	9.9	
3 04	400	9.9	10 g. Al_2O_3 added.
3 06	400	11.0	
3 08	400	10.1	
3 10	400	11.1	
3 13	400	11.1	
3 23	400	11.1	

Fresh cryolite added.

Time.	Current.	Volts.	Remarks
3 25	280	....	
3 35	380	. .	"Anode effect."

76 grams of aluminium were found in the crucible on cooling, corresponding to 36 per cent current efficiency.

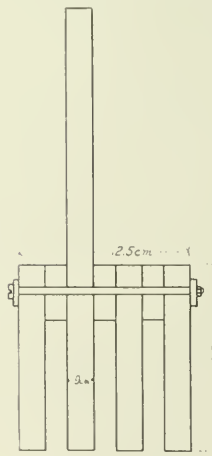
Evidently this was a slight improvement over the smaller crucible. It will be noticed that every time fresh cryolite was substituted for that already in the crucible the electrolysis started up again for a short while. Changing the anode did not have this effect. The trouble, therefore, seems to be caused by some change that takes place in the solution electrolyzed. The contents of the crucible is always darkened after the run and smells a little of acetylene, showing the presence of carbide.

It was found that the addition of neither sodium fluoride nor aluminium fluoride had the effect of starting up the current in the way that natural cryolite did. A carbon anode was also tried, but with the result that the "anode effect" appeared even sooner than with graphite.

In another run similar to the one just given where the temperature was about 1100° with an anode the size of Haber and Geipert's, 66 mm in diameter, no better results were obtained. In this case the liquid gradually thickened up after electrolyzing half an hour, and the current gradually decreased, when finally the "anode effect" appeared. Thirty fine grams of aluminium, corresponding to 38 per cent current efficiency, were obtained in this run.

It will be observed that with the larger crucibles the runs were, in general, more successful than in smaller ones. This suggested the idea that if the crucibles were made large enough the difficulties found with the smaller sizes would disappear of themselves, and that a minimum size of cell might be found by trial in which the electrolysis would take place satisfactorily.

Accordingly a cell was made of graphite plates clamped together with iron bands and made tight with a paste of carbon flour, water and molasses. This was dried in the hot closet before using. The inside dimensions were 14 cm x 20 cm. The anode consisted of four graphite anodes 5 cm in diameter.



ELECTRODE CONSTRUCTION.

The "anode effect" appeared here as before, however, and 650 amp was the largest value of the current during a run. This is evidently not much more than half that four electrodes should carry. Another trouble with this arrangement was that the cryolite was melted only around the anodes and gradually collected in the corners and solidified. However, more aluminium was obtained than in any of the previous cells.

Evidently the anode must be more uniformly distributed over the surface of the cathode so as to keep the cryolite melted in all parts of the box forming the cathode, it must have a large surface, and at the same time allow the gas to escape. These conditions, as well as having a somewhat greater cross-sectional area, are fulfilled by the anode shown in the accompanying figure.

It is seen to consist of four graphite plates 1.9 cm thick, in the form of a grid 12.5 cm in height, breadth and length. The cathode consists of a box 17.8 cm square made of graphite plates of the same thickness. The following experiment was carried out with this anode:

EXPERIMENT 3.

Time	Current.	Volts.	Remarks.
1:35	....	....	Alternating current applied.
2:00	500	....	Direct current. Cryolite melted only under two plates.
2:02	550	10.7	
2:08	600	....	20 g. Al_2O_3 added.

2:15	670	....	
2:16	200	....	"Anode effect." 20 g. Al_2O_3 added.
2:20	600	....	
2:22	750	....	
2:23	850	10.0	20 g. Al_2O_3 added.
2:27	....	....	" " "
2:30	910	9.9	Cryolite now melted under three plates. 20 g. Al_2O_3 added.
2:34	950	....	
2:37	....	....	"Anode effect." 20 g. Al_2O_3.
2:39	1000	....	
2:41	1000	....	
2:45	....	....	"Anode effect." 20 g. Al_2O_3 added and current started up.
2:49	840	....	
2:50	....	....	20 g. Al_2O_3. Cryolite melted under all plates.
2:54	....	....	20 g. Al_2O_3.
2:56	....	....	"Anode effect."
2:58	900	....	Al_2O_3 added. "Anode effect" on some plates and not on others. "Anode effect" on some plates and not on others.
3:00	930	....	"Anode effect." 20 g. Al_2O_3.
3:06	1000	....	
3:08	....	....	20 g. Al_2O_3
3:12	1010	....	" "
3:14	....	....	" "
3:15	1000	10.0	
3:18	....	....	20 g. Al_2O_3.
3:21	950	....	" "
3:22	900	9.1	
3:23	....	....	20 g. Al_2O_3. Getting too hot; voltage lowered.
3:27	810	9.4	
3:33	....	....	20 g. Al_2O_3.
3:35	950	8.4	
3:37	....	....	20 g. Al_2O_3.
3:41	900	8.8	Electrolyte seems thicker.

Up to this point over 2 kg of cryolite had been melted up. A layer of aluminium had collected at one point about as deep as the cryolite, and this was burning up.

The experiment was therefore stopped here, as no more cryolite was on hand to melt up and cover the aluminium already obtained.

On cooling over night the graphite box was taken to pieces and 260 grams of aluminium were obtained, consisting of one large piece of about 220 grams and the rest in several smaller pieces.

This corresponds approximately to 49 per cent ampere-hour efficiency.

From this experiment it is seen that though the troublesome "anode effect" appears, it, nevertheless, does not prevent carrying out a satisfactory run. This seems to be due to the form of the anode as well as to the increased size of the cell. As is noted under the column headed "Remarks" the "anode effect" may appear on one part of the electrode and not on the other, and thus the electrolysis continues on the unaffected part while it is made to disappear on the other by adding aluminium oxide and stirring up the solution with a graphite or iron rod.

The current which passed was sufficient to keep the temperature up to the desired point with no other heat insulation than a single surrounding layer of firebrick. The temperature was not measured, but appeared to be about 1000° C.

Since the object of this work was simply to find a cell in which this reduction could be carried out on a small scale as a laboratory experiment, and since this object was accomplished, no further experiments were considered to be necessary.

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The Problem of Bearing Metals.

BY SAM. K. PATTESON.

One hundred and sixty-five million pounds of bearing metal is the amount that has been estimated to be in actual use on the railroads of this country, and when is added to this the metal which is used on engines, shafting, in rolling mills and machinery of all kinds, the total would in all probability considerably exceed $50,000,000.

The constant increase in the demand due to wear and necessary replacements makes the question of supply one of the greatest importance. In addition, the quality of the bearings affects very largely the life of the machine itself, and in view of all these facts the value of intelligent and scientific treatment of the subject cannot be overestimated.

The data available is surprisingly meagre under the circumstances, and in very few cases is the composition of the bearing metal sufficiently considered with reference to the requirements demanded. In some cases the metals have been manufactured under patents and sold under trade names, but in the majority of cases they are made of scrap with very little care exercised in seeing that the proportions of the different constituents are the correct ones.

Probably this lack of available data is not equalled in any other branch of engineering progress to-day. As a result the purchaser is compelled to take his bearing metal on faith, especially in view of the fact that in most cases, particularly in small shops, means and funds are not at hand to make accurate tests of their qualities. Only the largest consumers, as a general rule, have the necessary appliances and even when these are at hand, the special knowledge which is required to conduct the test is often unavailable. The only recourse of the average consumer, therefore, is to depend more or less on the reputation of the firm furnishing the material.

A considerable variety of metals, with a greater range in proportion of each, exists in metals used for bearings. Copper, lead, tin, antimony and zinc are combined to form what are known as Babbitt metals, after the name of the man who discovered the advantages of such a combination, white metal, brass, phosphorous bronze and various other trade names. A great majority of them are sold merely under trade names, and in many cases there is a considerable variety in their composition, even though of the same brand and sometimes in the same shipment. "Plastic bronze" and a few others are sold under patents, but these form a minority of the total.

Bearing metals should have sufficient strength to withstand considerable strain and enough resisting power not to crack or break when subjected to heavy and sudden shocks nor to be crushed by pressure. In the selection of a bearing metal, however, special attention should be given to the local requirements.

The temperature plays a very important part here. If the metal is subject to extremes of heat and cold, with resulting contraction and expansion, binding may occur to such an extent that breakage may result from this cause. Again, extremes in temperature affect very seriously the brittleness, ductility, etc., of the metal.

Chemical action upon the bearings will also often result in injury, and in establishments, such as ammonia refrigerating plants or chemical factories, this factor should be borne in mind. These local effects are probably most severe in electrical machinery, where the bearings themselves must serve as electrical conductors, as in trolley cars and like installations. Elimination of friction and resistance to compression loads have supplied subjects for investigation in machine progress probably more than any other.

Thurston claims that all metals have the same frictions, and the value of the soft white alloys for bearings lies chiefly in their ready reduction to a smooth surface after any local injury which might result from the introduction of foreign matter between a bearing and the pulley or moving surface. The

it very is rapidly filled up by the metal flowing into it forming a larger area for the distribution of the pressure, and hence reducing the possibility of overheating, since the larger the bearing surface the less the likelihood of heating.

Hence, the lower the frictional properties of a bearing the less will be its compressive resistance to shocks and invariably alloys best suited for bearings from an anti-frictional, and, hence, speed point of view are the least satisfactory for utilization in heavy machinery units. To overcome this difficulty an iron or steel grid has been recently introduced to form the base of the main bearing. This is filled with a much softer bearing metal than could be used under ordinary circumstances. This is a distinct step in the right direction and presents possibilities of great importance.

A number of metals possess good anti-frictional qualities, but lead is the first one on the list which is practically available, owing to the high cost of the others. Excluding, therefore, the costly ones, lead has the greatest anti-frictional properties of the available metals due to the fact that it flows more easily under pressure

Lead, with the exception of iron, is the cheapest of the metals. The various metals suitable for use in the formation of bearing alloys are somewhat as follows:

Lead,	per	100	lb	$4.00
Zinc,	"	"	"	5.00
Copper,	"	"	"	13.00
Tin,	"	"	"	30.00, sometimes more.

Thus, the more lead a given bearing contains the softer it is, the better its anti-frictional qualities, and the cheaper it will be.

Lead cannot be used alone, however, as it cannot be retained in the recesses of the bearing, and various other metals have been alloyed with it, such as tin, antimony, copper, zinc, iron and a number of known metallic substances, such as sodium, phosphorus, carbon, etc

Experiments with these different compounds have given a fairly adequate amount of data as to their varying effects. Thus, antimony and lead produce a hard and brittle alloy. If tin is added to this it is toughened to a considerable extent. These three constituents are most common in the various bearing metals on the market.

If the proportion of antimony is increased, better wearing qualities and greater compressive strength result, making it more suitable for heavy machinery. Less antimony and more lead form a combination which is especially suited for high speeds because of the better anti-frictional qualities of the lead. While the addition of tin will increase the toughness of the bearing, it will also considerably increase the cost.

The steady increase in speed in the development of modern machinery creates a wide range of duty for the bearing metal. The chief obstacle to the development of the modern turbine lies in the difficulty in securing proper bearing surfaces. Soft babbitts are required for high speeds, and soft babbitts will not stand the shock and strain of heavy machinery. On the other hand, the harder babbitts suitable for heavy machinery present too great frictional properties, and it can be said that on the solution of these problems depends the increase in size and speed of machinery to-day.

Another phase of the subject which has probably not received the attention which it seems to warrant is the effect of temperature on the bearing properties of the alloys. Means for maintaining proper temperatures would undoubtedly result in great improvement. This subject is being investigated more especially in regard to turbine construction, however, since the speed in this development made the bearing problem an acute one. In fact, the efficient operation of the turbine can be said to depend upon a satisfactory solution of this question.

The following table gives in a general way the composition of the bearing metals commonly found on the market to-day.

Alloys.	Lead.	Tin.	Antimony.	Copper.	Zinc.	Other constituents.
Babbitt 1	80.0	20.0	...	...	...	.....
Babbitt 2	72.0	21.0	7.0	...	...	.....
Babbitt 3	70.0	10.0	20.0	...	...	.....
Babbitt 4	80.5	11.5	7.5	0.5	...	.....
Babbitt 5	68.0	...	1.0	31.5	...	.....
Babbitt 6	...	20.0	...	...	80.0	.....
Babbitt 7	...	86.0	10.0	4.0	...	.....
White metal	82.0	...	12.0	6.0	...	.....
White brass	...	64.0	...	2.0	34.0	.....
"Magnolia metal"	80.0	4.75	15.0	trace	...	Bi = 0.25
Car brass lining	80.5	11.5	7.5	0.5	...	.....
"Ajax plastic bronze"	30.0	5.0	...	65.0	...	.....
"Ajax metal"	11.5	...	...	77.0	...	.....
P. R. R. car brass	15.0	8.0	...	77.0	...	.....
"S. bearing metal"	9.5	10.0	...	79.7	...	P = 0.80
"Delta metal"	5.1	2.4	...	92.4	...	Fe = 0.1
"Carmelia metal"	14.8	4.3	...	70.2	10.2	Fe = 0.5
Tempered lead	98.5	0.08	0.11	...	...	Na = 1.30

The above table shows a wide variation in the composition of the various babbitts. The babbitt metal originally put on the market was a very expensive material. The cost, however, has been greatly reduced.

The first metal on the list, 80 per cent lead, is not a very hard one, but one that is suitable for high speeds. Its melting point is about 500° Fahr. In a general way the properties of all bearing metals can be readily deduced from their melting points.

The second babbitt is somewhat harder, containing 7 per cent antimony, and a slightly larger per cent of tin than the first. These two babbitts are favorites for lining purposes.

The fourth babbitt contains 20 per cent antimony and is still harder. It is suitable for heavy machinery and is widely used for that purpose.

No. 6 has good wearing qualities, but is too hard for high speeds. In fact, all the babbitts will give satisfactory results in the positions for which they are especially suitable.

The white alloys possess a fairly good electrical conductivity Tempered lead is harder than pure lead, but its anti-frictional qualities are supposed to be great, owing to a somewhat novel development. In operation the caustic soda formed by oxidation of the sodium in the bearing metal saponifies with the oil and thus assists lubrication. The extent to which this phenomenon affects beneficially the operation of the bearing has not been determined.

The other alloys given contain varying proportions of copper, tin, and lead, and when lined with a thin layer of lead or some soft babbitt, wear much better than the softer metals. A large percentage of lead in an alloy tends to decrease the frictional effects, but pure lead is too soft to be used alone, and a certain proportion of other material is necessary.

The addition of tin increases the frictional effects and also increases the wearing qualities. Pure copper itself is so tenacious that it is practically impossible to work it with any tools without prior treatment and this property affects the bearing quality of any allow of which it forms a part.

The above gives a general review of the bearing metal situation as it exists to-day. The possible variations in the composition of bearing metals are innumerable. Comparatively little data is available on this subject. A large number of metals, such as calcium, have been recently placed on the market, many of which possess very suitable properties for bearing metals, and this development is bound to influence the situation.

Interest is increasing in the scientific solution of the problem and various improvements along various lines may be looked for in the near future. Such devices as the steel grid and similar developments are steps in the right direction and will undoubtedly aid in the solution of the problem.

Perkin Medal.

The Perkin Medal Committee has awarded the medal for the year 1909 to Dr. Arno Behr, Pasadena, Cal., for his valuable work in the glucose industry. The official award will be made at the January meeting of the New York section.

The Thermal Production of Ozone.

BY ARTHUR W. EWELL.

Franz Fischer, of Berlin, has recently demonstrated that ozone is produced when oxygen is raised to a high temperature. His methods have not as yet reached the high efficiency obtained by other processes, but the work is very promising. Fischer has shown his own belief in the ultimate success of thermal production by securing a broad patent covering such processes, and this patent has apparently been transferred to the Allgemeine Elektricitäts Gesellshaft[1].

The subject is particularly interesting to students of physical chemistry, because it illustrates the frequent ultimate technical value of experimental and mathematical investigations, which, by themselves, appear only of theoretical importance.

Some five years ago, at a scientific gathering at Cassel, Nernst announced that the equilibrium concentration of ozone increased with the temperature and that he had calculated the normal concentration to be as follows[2]:

Temperature Centigrade	1910	2957	6367
Concentration of Ozone (per cent)....	0.1	1	10

That is, for every 1000 grams of oxygen at 1910 degrees, there will normally be one gram of ozone.

It is not difficult to see how these figures were obtained. Suppose a mass of oxygen is allowed to remain under constant conditions a sufficient time for the equilibrium amount to be transformed into ozone. Let us calculate the difference of potential between the ozone and the oxygen, for, in general, two dissimilar bodies, in contact and in equilibrium, will be at different electrical potentials. Berthelet[3] found that 29,600 calories were required to form one gram-molecule of ozone from oxygen. If this potential energy were completely transformed into electrical energy we should have

$$4.19 \times 29.600 = 2 \times 96,500 \times E$$

where $2 \times 96,500$ is the quantity of electricity associated with one gram-molecule, 4.19 is the factor to change calories to joules, and E is the above natural difference of potential. Solving, we find E is 0.64 volt.

Grafenberg[4] and Luther[5] have measured the difference of potential between a platinum electrode which has absorbed ozone and one which contained hydrogen, and also the minimum potential required to liberate ozone in electrolysis. After allowing for the difference of potential of the hydrogen electrode, their results agree quite closely with 0.64.

If we regard this natural difference of potential as due to the difference in concentrations of the ions in oxygen and ozone, we may employ Nernst's concentration equation:

$$E = \frac{RT}{e} \ln \frac{c_1}{c_2}$$

where R is the gas constant, 1.98 joules, T is the absolute temperature, e is the charge associated with one gram-molecule, c_1 is the concentration in the oxygen and c_2 is the concentration in the ozone.

We will assume further that the heat of formation of ozone varies little with the temperature, i. e., that E is constant, and that the concentration of the ions in the two gases is proportional to the concentration of the gases. Hence, changing to common logarithms, we have:

$$0.64 = \frac{1.98 \times 2.30}{2 \times 96,500} T \log \frac{c_1}{c_2}$$

If we substitute $c_1/c_2 = 100$, T comes out 3230, or 2957 degrees Cen., and the two other results in the above table are similarly obtained. (I the equations above are examined, it will be noticed that the charge, which is assumed as two faradays, cancels out. Great importance should not, however, be given the results in the above table, on account of possible inaccuracy in Berthelot's work and uncertainty regarding the hydrogen electrode.)

Dr. Clement[6], working under Nernst, attempted to obtain ozone by heating oxygen to high temperatures. He obtained a gas which set free iodine and which shows other resemblances to ozone, but upon testing with tetrabase paper[7] he always obtained the yellow color characteristic of oxides of nitrogen, and never the violet color which characterizes ozone.

Nernst attributed his failure, not to incorrect theory, but to insufficient rapidity of cooling. If the mixture of ozone and oxygen, which is stable at a high temperature, is cooled suddenly to a low temperature, it remains at practically the same composition. For, although at ordinary temperatures the equilibrium concentration of ozone is almost infinitesimal, yet the decomposition toward this concentration is exceedingly slow compared with the rapidity with which the equilibrium concentration is reached at higher temperatures. If the ozone and oxygen are not removed almost instantaneously from the high temperature region, the product obtained will correspond to a comparatively low temperature, and the content of ozone will be inappreciable.

The equilibrium between ozone and oxygen subjected to the silent discharge is totally different. Warburg[8] has shown that here the equilibrium concentration of ozone increases with decrease of temperature. Briner and Durand[9] obtained pure ozone by means of the silent discharge at the temperature of liquid air.

It is unfortunate that we cannot analyze the gas at high temperatures. The change of volume corresponding to the formation of ozone is too small to measure accurately. Warburg's beautiful work upon absorption spectra suggests that possibly some information might be obtained by this means.[10]

Franz Fischer repeated Clement's work in the chemical laboratory of the University of Berlin, with such modification as would give a greater velocity of cooling.[11] He tried first various flames (hydrogen, acetylene, etc.) over liquid air or oxygen. Ozone was always found dissolved in the liquid, and with liquid air solid crystals of oxides of nitrogen were also formed. Next platinum was maintained at incandescence in liquid air or oxygen, and traces of ozone were found, although the experiments were somewhat unsatisfactory on account of the rapid destruction of the platinum.

An electric arc was maintained in liquid air and ozone was found, either dissolved or as dark blue globules. Finally, a Nernst glower was heated to normal brilliancy in liquid air or oxygen and a large amount of ozone was obtained.

The expense and inconvenience of using liquid air or oxygen led Fisher to seek a more practical method.[12] Clement's experiments, where oxygen traversed incandescent bodies, were repeated with far higher velocities. The maximum velocity used by Clement was 1 m. per second. Fischer worked up to 90 m. per second. The air or oxygen emerged from a slit a few tenths of a millimeter wide and impinged upon a Nernst glower a few millimeters from the slit. The heated gases then entered a glass tube surrounded by cold water.

When the velocity was less than 5 m. per second, no ozone was formed, but a large amount of oxides of nitrogen was produced. As the gas velocity was increased, an increasing yield of ozone was obtained, at 7 m. per second the ozone began to predominate, and at 30 m. per second no nitrogen oxide could be detected. Therefore, both the formation and the decomposition of ozone are more rapid than that of oxides of nitrogen. If the velocity was too great, e. g., 76 m. per second for a 0.1 mm slit, the ozone has insufficient time to reach the equilibrium concentration, and the yield decreases.

The highest concentration and the greatest efficiency were

[1] *Journal Soc. Chem. Ind.*, 1907, pp. 608, 872.
[2] *Zeit. für Elektrochemie*, 1903, 7, p. 891.
[3] *Comptes Rendus*, 82, p. 1281.
[4] *Zeit. für anorgan. Chemie*, 36, p. 355.
[5] *Zeit. für Elektrochemie*, 2, p. 832.
[6] *Ann der Physik*, 1904, 14, p. 343.
[7] Arnold and Mentzel, *Central-Blatt*, 1902, 2, p. 1240.
[8] *Ann. der Physik*, 1902, 9, 1286; 13, 1080.
[9] *Comptes Rendus*, 145, 127.
[10] *Preuss. Akad.*, 1908, 6, 148.
[11] *Berichte deutsch. chem. Gesell.*, 39, 940-968
[12] *Berichte* 39, 2557-2566, 3631-3648; 40, 443-458, 1111-1120.

[illegible] a velocity of 57 m. per second (1 mm slit) and the highest feasible temperature, 1930° C. Under these conditions 3.60 mg of ozone were produced in 100 seconds in 10 liters of air. The concentration was, therefore, 0.029 per cent by weight, or 1.2 per cent of the atmospheric oxygen. The Nernst glower [illegible] 5 amp at 123.5 volts. The commercial efficiency, or the yield in grams per kw hour, was, therefore,

$$\frac{0.0030 \times 3600 \times 1000}{0.5 \times 123.5 \times 100} = 1.3$$

[illegible] of air 92 per cent oxygen was used, the percentage of oxygen changed to ozone was much less, under similar conditions, but the commercial efficiency was a little higher. In the earlier experiments, where the cooling was accelerated by the use of liquid air, a commercial efficiency of 3.5 grams of ozone per kw-hour was obtained for a concentration of 0.12 per cent and 2 grams for a 1 per cent concentration.

Let us compare these yields with those obtained by the silent discharge at ordinary temperatures[1] and by electrolysis.[2]

YIELD IN GRAMS PER KW HOUR.

Concentration (gr per cu. m.)	Thermal (blast)	Thermal (liq. air)	Electrolysis	Points —	Points —	Dielectric
17	1.3	...	..	60	40	70
18	...	3.5	..	50	37	55
14	...	2.	..	..	10	..
29	...	...	70	..	..	..

However, at present the thermal production of ozone is relatively inefficient, but when it has received as much attention as has been devoted to the other methods, great improvements may be expected.

Many of the above phenomena may easily be shown in a lecture room. Remove the outer casing from a single glower Nernst lamp. Procure a seamless brass tube about 6 mm internal diameter and 1 cm external diameter, crush one end together and file away until there is a straight slit about 0.1 mm wide and 1 cm long. File away one side almost to the slit, so that it can be brought close to one of the heating tubes, and about 2 mm from the glower. By means of an ordinary foot-bellows drive a current of air through the slit upon the incandescent glower. The odor of ozone or oxides of nitrogen will soon be evident, and may be demonstrated to a class by holding in front of the blast and as close as possible to the glower, a paper saturated with starch iodine solution. The characteristic blue color will soon appear.

Since the yield of ozone decreases greatly with increase of moisture, it will be of advantage to dry the air between the bellows and the slit by passage through calcium chloride tubes. A tube filled with glass wool next the slit prevents clogging by foreign particles. If a manometer is inserted, next the slit, the velocity of the air may be calculated from the formula $v = \sqrt{2p/d}$, where p is the pressure in dynes per square centimeter, and d is the density.

An organic chemist can readily prepare tetramethyl-*p*-*p*'-diamido-diphenylmethane (tetrabase). A paper soaked with an alcoholic solution, held in the blast close to the glower, will turn yellow at low velocities, and at high velocities a bluish violet the former signifying oxides of nitrogen and the latter ozone. The starch iodine paper turns blue with both.

If the drying tubes are replaced by a gas washing bottle containing water, the tetrabase paper will not be affected, showing the absence of ozone and oxides of nitrogen. Starch iodine paper will be colored to practically the same degree as before, because hydrogen peroxide is now produced in considerable amount.[3]

Worcester Polytechnic Institute.
December, 1908.

[1] Warburg, Wied. Ann. der Phys., 9, p. 734. Ewell, *Phys. Rev.*, 1906, February, p. 81; April, p. 232. *The Journal of Sc.*, 1906, November, p. 368. *Phys. Zeit.*, 1906, 25, p. 920. This journal, 1907, July, p. 264.
[2] Zeit. angew. Chemie, 1907, 52, p. 229.
[3] Berichte, 1906, 39, p. 3631.
[4] Zeit. anorg. Chem., 1905, 44, p. 945.

Silundum, a New Product of the Electric Furnace.

By F. Bölling.

Moissan describes in his well-known book on the electric furnace a test made by him, as follows:

"Ces tubes de charbon ont le grave inconvenient de presenter une porosite notable; nous avons cherché à l'eviter le plus possible, en employant des tubes doubles ou des tubes recouvert de magnesie. Tous les essais tentés pour foudre à leur surface une couverte de silicure de carbon, de borure de carbon, ou d'autres carbures, ont été infructueux. Nous poursouvions cependant ces études, car il est très utile pour les récherches délicates qui restent à entreprendre aux temperatures élevées de preparer des tubes d'une etanchéité parfaite."

Moissan intended to cover a tube of carbon with a layer of silicon carbide (carborundum). His purpose was to obtain a gas-tight tube, assuming that silicon carbide could be melted, while in reality this material behaves in this respect like carbon. Supposing that Moissan had obtained a deposit as desired, he would have found it to be as porous as the carbon.

I have referred to Moissan, for if he had succeeded he would have been able to produce years ago the material which is the subject-matter of the present article.

Since 1900 the writer occupied himself with the use of silicon carbide for resistances that would stand very high temperatures. Many experiments were made, mixing silicon carbide powder with bonds of the various compositions to bind the individual crystals of the powder together. These bonds were non-conductors at low temperatures, but at about 700-800° C. the bond and with it the entire resistance body became conductive, with the result that the resistances could not be used for very high temperatures. The experiments were suspended, but taken up again in 1904, with the result that a procedure was worked out and patented, by which it is possible *to convert any piece of carbon, for instance, in form of rods, bricks, crucibles, into silicon carbide.* Resistances are thus obtained that have no binding materials and will stand temperatures as high as 1650-1700° C.

Silicon carbide was known so far only in the amorphous or crystalline state, and it was supposed that it was formed by the sublimation of carbon and silicon. The writer, however, discovered *that silicon penetrates into carbon when both are in a highly heated condition.* The silicon at about 1600° C. exists only in the form of vapor, while the carbon at this temperature keeps its shape, it being understood that air has access neither to the one nor the other.

Silundum, as the new material has been named, or silicified carbon, is therefore *a product that is obtained when carbon is heated in a vapor of silicon.*

For the production of this material electric furnaces are used, of the same kind as for the manufacture of carborundum. The pieces of carbon of the various shapes are introduced into a mixture of sand and carbon, that is acted upon by a granular core of coke as conductor for the electric current. Instead of sand and carbon, amorphous carborundum can be used, enriched with sand, to provide for the necessary silicon for the carbon pieces to be converted into silundum.

The silicification of the carbon depends on the time and the temperature employed. It is possible to entirely silicify the carbon pieces or to cover them only with a layer of silundum.

This layer may be of any thickness desired. The shape of the carbon article acted upon remains entirely unchanged. It leaves the furnace in the same shape as it was introduced, and manufacturing marks that are pressed on the carbon remain distinctly visible. Tubes of carbon can be silicified inside and outside. Silundum tubes of any thickness of wall and of any diameters, as obtainable from carbon manufactures, are made in silicifying a solid carbon rod, leaving a core of carbon inside, which is burned away in a furnace, which communicates with

the air, leaving thus a tube of silundum. It is possible to make round, square or flat tubes.

If it is desired that one part of the carbon piece remains carbon on one spot, this place is shielded by another piece of carbon, thus preventing the silicon from penetrating into that particular spot. Lamp filaments can be easily converted into silundum or only covered with a layer of silicon carbide. Charcoal is very easily converted into silundum; so is coke, because both are very porous.

The silicification takes place easier with porous carbon pieces than with pieces that are pressed very hard and tight and baked. Graphite is easily silicified. Carbon powder compressed at very high pressure can be silicified without being baked first. In order to accelerate the process of silicification, the pieces can be made of carbon and amorphous or crystalline carborundum, bound together with tar or any other bond that contains carbon.

This modification may be used in cases where very large pieces, bricks or the like, are to be converted into silundum.

Instead of using carbon and sand or amorphous carborundum and sand, the pieces could eventually be laid in molten silicon. It is quite natural to think of this means to convert the carbon pieces into silundum, but, as it is cheaper and easier to obtain the necessary silicon from the sand, this idea was abandoned.

For the production of this material cheap current is desirable, at least for larger pieces, while the price of the electric energy is of not so great importance, where smaller rods up to four or five millimeters diameter come into consideration. The material is produced at present in a plant in Switzerland that has been erected for this purpose.

PROPERTIES OF SILUNDUM.

Silundum is another form of silicon carbide and it has generally the same properties. It is very hard; it resists temperatures up to about 1600° C. when heated in air and does not oxidize. It resists the attack of acids when cold and is a conductor of electricity, its resistance being several times that of carbon.

The hardness of silundum is variable and depends on the zone around the core of the furnace in which it is produced. Material from the amorphous zone is less hard than that obtained in the crystalline zone. It may be assumed that the hardness depends on the temperature in which the material is produced. The hardness may also depend on the amount of silicon taken up by the carbon. It seems that some pieces contain more or less silicon than others, but no analysis was made to ascertain this.

In regard to the fireproof qualities of silundum, it may be mentioned that at about 1700° C. the silicon leaves the carbon and combines with the oxygen of the air. Small transparent globules are formed (for instance, on a rod that is put in a circuit and heated to about 1700° by the electric current) on the surface, of clear or brownish color. These globules are silicon dioxide. Parts of the silicon escapes in form of a white vapor.

Silundum cannot be melted, and it behaves in this respect like carbon. The electric resistance of silundum is variable and depends on the kind of carbon and its hardness. Silundum made from porous carbon has a higher resistance than when made of hard carbon. The resistance depends also on the modification of the material. If produced in the amorphous zone the resistance is generally higher than in the crystalline zone.

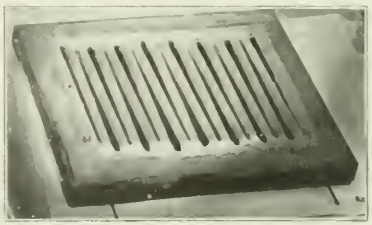
USES OF SILUNDUM.

The first use for which the material found application was for electric cooking and heating purposes. For this use the experiments that led to the invention were made.

The electric heating industry for domestic as well as for industrial purposes demands, for a large number of appliances, a higher temperature than can be obtained by ordinary resistance wires. Platinum, of course, can be used, but this material is very expensive, especially so when thick wires or ribbons are used, as should be done, of sufficient mechanical strength. Silundum replaces platinum for this purpose and is much cheaper.

Electric cooking and heating industries have developed in the last five years enormously and will continue to do so. Any reduction in the price of electric energy will result in a greater demand for electric ranges, which may be used for cooking just like gas ranges. The electric range demands, however, a concentration of electric energy to be converted into heat that can hardly be obtained at present with any system without overheating the resistors or without increasing the weight of the heating plate, with the result that the preparation of a meal requires too much time, in comparison with heating by gas or coal. Silundum stands very high heat, does not oxidize and can be used with the necessary high temperature needed for the purpose. Ranges are produced that have the glowing heat of a coal fire and they are used exactly as those heated by coal.

For industrial purposes there is a large field for heating apparatus for melting metals, brass, aluminium, lead, tin, etc., and for electric laboratory ovens for high temperatures, and it is especially for this purpose that the material fills a long-felt want. Platinum and platinum-iridium has been used to a great extent for laboratoy ovens, but such apparatus are very expensive and they can be repaired only at great expense.



SILUNDUM

Silundum can be used with just as high temperatures as platinum and its price is low. The first cost of the apparatus as well as the expense for repairs are considerably lower than with platinum.

For heating purposes the silundum rods can be used single in lengths up to 800 mm, depending, of course, on the diameter, as solid, round, flat or square rods or tubes or also, as shown in the adjoining illustration, made into grids, mounted in a frame and provided with contact wires. The purpose of the present article is not to show the numerous constructions of electric heating apparatus that have been and are made with silundum, but only to describe the material and its uses.

Silundum stands just as well as silicon carbide the attack of acids, and experiments are now being made to use it as electrodes for electric bleaching purposes instead of platinum-iridium, carbon or graphite. In order to prevent the oxidation of carbon electrodes used for the manufacture of ferrosilicon, it has been proposed to cover these electrodes with a layer of silundum.

Silundum can be nickel plated or covered with a layer of platinum.

Silundum is a very refractory material and does not melt. It is, however, attacked at high temperatures by molten metals, but this should not prevent its use as fireproof material, for it is easily possible to cover the outside of a carbon or graphite crucible or the like with silundum and leave the inside carbon. It is not necessary to silicify pieces to be used for fireproof purposes entirely, but only to a certain depth and according to the use for which they are to be employed. Carbon bricks or any shaped pieces can be covered with a layer of silundum at small cost. It is thus possible to obtain a material that for many purposes will be far superior to any fireproof material known so far.

Silicified coke can be used instead of ferrosilicon or carborundum in the steel industries, and, as it can be produced at very low cost, it will doubtless find extended application.

In conclusion, I may say that I have tried carbon filaments covered with silundum and filaments entirely converted into silundum, but found that when used in a vacuum the globes soon were covered with a brownish or black layer, very likely of silicon. I may also add that if a carbon filament is first silicified and the silicon driven out again by overheating it a graphite filament remains that has very valuable qualities.

Frankfort on the Main, Germany

Three New British Aluminium Works.

The present crisis in the aluminium industry and the fall of the price of aluminium in London to the level of copper has been chiefly due to outsiders entering the field of aluminium manufacture in various European countries and crossing the purposes of the formerly almighty international syndicate, which has now been dissolved. While these new works of the independents were opened, the old syndicate plants also made very considerable extensions. This resulted in overproduction, which was further accentuated by a reduced demand due to last year's industrial crisis. The present situation in the aluminium industry is the natural outcome.

A description of two new aluminium plants, erected by the Aluminium Corporation, Ltd., in Great Britain (a new company outside of the old syndicate), and of a large new works of the British Aluminium Co. (a member of the old syndicate) is, therefore, of timely interest. The following description has been prepared from articles in the (London) *Electrical Review* of Nov. 6, the (London) *Electrical Engineering* of Nov. 17, and the (London) *Electrician* of Dec. 4, as well as from private information received from British correspondents.

FIG. 1.—ALUMINIUM PLANT, DOLGARROG.

Dolgarrog Works.

One of the new works of the Aluminium Corporation, Ltd., is located at Dolgarrog, six or seven miles from Conway, in North Wales. The principal source of electric power is a water falls with a head of over 1000 ft., and a supplementary supply of power is obtained from a high-voltage transmission line of a power company.

The power plant contains four Pelton wheels, each coupled directly to two 500-kw direct-current generators. The two machines of each set are connected permanently in parallel and the total output per set is 8000 amp at voltages varying up to 125 volts. In addition, the station contains two motor-generators which change the alternating current of the transmission lines into direct current. The motor half of each set is a three-phase induction motor, while the generator half of each set consists of two 300-kw direct-current generators. The total available power of the plant is, therefore, 5200 kw.

Immediately behind the power house in the same structure, but separated from it by a wall, are six bays, five of which contain the aluminium tanks or electrolytic furnaces, while the remaining bay is devoted to the recasting of aluminium ingots into the various forms required by commerce and to storage purposes. There is a total of 125 aluminium furnaces in these works, whose aggregate capacity is about 1600 tons of metal per year.

FIG. 2.—CARBON WORKS, WALLSEND.

The continuous nature of the work imposed on the electrical plant by the requirements of the electrolytic process rendered it necessary to build the dynamos in accordance with very stringent conditions. In the first place, precautions had to be taken against the unfavorable climatic conditions; for the greater part of the year it rains heavily, and the atmosphere, in consequence, is extremely damp.

The four dynamos have to run day and night at their full rated capacity of 8000 amp. At starting, the pressure is gradually raised from 0 to 40 volts, when the furnaces are switched in. Between 40 and 138 volts the regulation has to be so fine that the pressure can be raised volt by volt.

The normal pressure of the dynamos when running at 450 revolutions per minute is 125 volts, but the machines, even when hot, can give a pressure of 138 volts with a current of 8000 amp each for one hour. Moreover, they can give any current between 0 and 8000 amp at any pressure between 0 and 138 volts, with absolutely sparkless commutation, after 24 hours' run on full load.

The furnace room is lofty and well lighted, and is some 200 ft. long by 160 ft. wide. Along the wall immediately adjacent to the generating sets runs a pair of copper busbars 8 sq. in. in section. These bars are only intended to be used occasionally as "hospital-bars," or for coupling together any desired machine or furnace circuit.

Ordinarily, each line of furnaces will be fed from its own machine through massive connections coming direct through the wall. These main connections are each of 16 sq. in. section aluminium, built up of eight bars, each 4 in. by ½ in. From each of these, a set of eight 1-sq. in. flexible copper cables lead to the furnaces. These are arranged in groups of 25 connected in series, and taking a working current of about 7500 amp, but the groups can, of course, be subdivided if required. Five such groups will eventually be installed, and of these three are already erected.

Thus, when working at full power, each water-driven machine will run one group of 25 furnaces with a pressure of from 120 to 130 volts, across the terminals of the group, while the remaining group of 18 furnaces will be run off one of the motor-generators, which work only up to 75 volts. In practice, however, various other combinations can be made.

The behavior of each furnace can be studied by means of a conspicuous low-reading voltmeter, with which each is provided, and which indicates the voltage drop across the terminals of the furnace. (These low-reading voltmeters are a

substitute for low-voltage incandescent lamps used elsewhere. Such lamps connected across the tanks or furnaces are dark as long as the voltage is so low as to correspond to the proper decomposition of the alumina dissolved in the bath. When the alumina is used up, the voltage rises and the lamp lights up, indicating to the workingmen the necessity of adding more alumina.)

Wallsend Works.

It is possible that the Dolgarrog works would have attained more than their present importance, had not the company received from the district of Newcastle-upon-Tyne such favorable proposals and terms for electric power supply that it was decided to erect a second plant at Wallsend, not far from the Carville generating station of the Newcastle-upon Tyne Electric Supply Co., Ltd.

FIG. 3.—PRELIMINARY MINING WORKS AT ST. BARNABE BAUXITE MINE.

An area of about 3½ acres, adjacent to the water front of the river, was taken and cleared of existing buildings, the foundations of the aluminium works and of a plant for the manufacture of carbon electrodes being laid in August, 1907. The work proceeded with such speed that at the end of February of 1908 the carbon works were in full operation, while the first metal was run from the aluminium furnaces on March 11.

Electrode Plant.—In order to obtain an idea of the arrangement of the works it is necessary to start with the carbon works, where the electrodes to be afterwards used in the furnaces are made. The raw materials used are oil, coke, retort carbon and pitch. These are brought to the works by water and are placed in a store adjacent to the wharf, capable of holding 200 tons of coke.

The oil coke is first calcined and then, together with the retort carbon, is passed through crushing machinery and reduced to a fine powder. This is then taken to mixers and incorporated with heated pitch in a liquid condition, afterward being placed under hydraulic pressure of 1 ton per square inch, and pressed into carbon blocks. The mixing machines and rams were made by Messrs. Wilson & Sons, of Johnstone, N. B.

The opportunity is taken in this process of inserting the iron bar which is to form the contact of the electrode in the furnace. These blocks of carbon, measuring approximately 10 in. x 10 in. x 12 in., are then placed in batches on trucks 6 ft. long and put into carbonizing furnaces, through which the trucks are gradually pushed forward by means of hydraulic rams, one truck pushing another till the complete passage has been made, taking a week or ten days.

The furnaces are three in number, each of about 4 to 5 tons capacity per day, and are each 190 ft. long, in the form of a horizontal kiln or flue, heated by means of producer gas. For this purpose three Dawson gas producers, with the necessary auxiliary plant, are installed.

After the trucks have passed through the furnaces they emerge into a cooling room, where the trucks are cooled down to a reasonable extent, and the baked carbon blocks are taken off and stored. Provision has been made to manufacture electrodes up to 5 ft. long, and powerful plant is installed for the purpose. In these carbon works the electrodes are made for both the Wallsend and the Dolgarrog works.

Aluminium Furnaces.—The manufacture of aluminium depends upon electrolysis at a temperature of 900° to 1000° C. of a bath consisting of alumina (Al_2O_3) dissolved in cryolite, a double fluoride of sodium and aluminium ($Al_2Fl_6.6NaFl$).

The alumina is at present obtained by the Aluminium Corporation in the open market; but before very long refined bauxite will be prepared by an affiliated company, the Bauxite Refining Co., Ltd., of Hebburn-on-Tyne, reference to whose operations will be made below.

Electric power is obtained from the Newcastle-upon-Tyne Electric Supply Co., Ltd., to the extent of 4000 kw, the supply being brought direct from Carville at 6000 volts to the substation on the works; a single-unit system feeding to the machines has been adhered to, with provision for coupling the feeders across in the substation.

This substation is arranged with reference to the furnace room precisely as at Dolgarrog. Four bays in the furnace room, which are 133 ft. wide and 160 ft. long, stand at right angles to, and are separted by, a wall from the power station, where are installed the motor-generators. The capacity of the aluminium furnaces installed is about 1000 tons of metallic aluminium per year.

In addition to this, furnaces are now erected for the manufacture of ferro alloys, such as ferrochrome of various grades, ferrosilicon, etc., and also electric steel. These processes are believed to lend themselves especially well to the electrochemical operations of the firm, and the furnaces now being built are more powerful than the aluminium furnaces, the power required for each varying from 400 hp to 1200 hp. The furnace room and power house stand on rising ground, so a lift has been installed for the transport of material to and from the furnace room. (The fact that these works are taking up the manufacture of ferro-alloys is perhaps significant. The same development took place some years ago when the calcium-carbide boom collapsed in Europe and carbide plants stood idle. But at that time manufacture of ferro-alloys was virgin soil.)

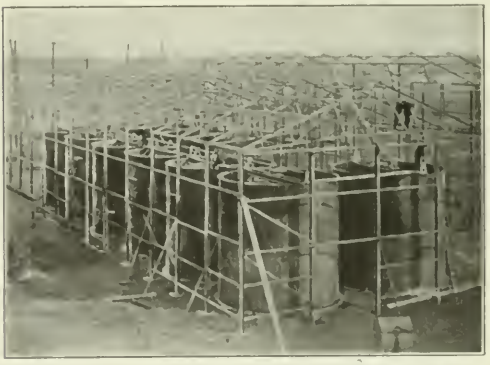


FIG. 4.—HEBBURN WORKS (FILTER PRESSES AND CONSTRUCTIONAL WORK).

After the aluminium metal has been run out of the furnaces into molds in the form of crude product ingots, these are passed to the stores; afterward they are taken to the recasting shop, where they are cast into the various market products, such as large bars in various sizes, billets for drawing into wire or rolling into rods, and tube billets for drawing into tubes. These special forms are made up as the order comes along, stock being usually kept in the form of ingots.

The recasting and alloy room contains three furnaces of special design, two being rotating furnaces with natural

draught, fired by producer gas, and the other being a tilting furnace by the Morgan Crucible Co., Ltd., for alloys, the blast being obtained by a motor-driven fan.

All classes of aluminium alloys are here produced for casting, rolling and general work, including aluminium bronze. Two of the most useful of the series are the Aluminium Corporation's "D alloy" and "F alloy." The former is an aluminium, zinc and copper alloy, giving a white casting metal that flows well and gives clean, sharp castings. It is used for motor fittings that have to be machined, and is especially good in sand or chilled molds. The latter is a copper-aluminium alloy much used for motor and cycle castings, being capable of bending and riveting cold.

At the Wallsend works is situated the chemical laboratory in which samples of all raw and finished materials handled by the

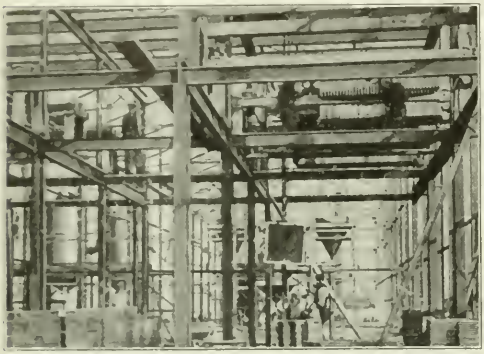


FIG. 2.—PORTION OF HEBBURN WORKS, IN COURSE OF CONSTRUCTION.

corporation are tested. The aluminium produced is of very high quality, in no case falling below 99 per cent of the pure metal.

Bauxite Works.—As noticed above, the Aluminium Corporation is about to obtain its alumina from an affiliated concern in Hebburn. The works of the Bauxite Refining Co., Ltd., which are just nearing completion, will be capable of turning out from 4000 to 6000 tons of alumina or refined bauxite per year, but are being designed so that their output can be doubled when required. In view of the present low price of aluminium it is of greatest importance to secure a supply of refined bauxite at the lowest possible rates.

The Aluminium Corporation have achieved this by obtaining valuable properties in the Var district, in the south of France where the best quality of bauxite, containing about 62 per cent of alumina and a very low proportion of silica, is found. They have at present in operation two bauxite shafts at St. Barnabe, near Sillans, the preliminary mining works for which are shown in Fig. 3.

About 50 French and Italian workmen are employed in mining the bauxite, which is then shipped to Toulon and thence to the Hebburn works. The special advantage of this arrangement is that cargoes of coal are already in great demand in the Mediterranean, and the colliers bring back the bauxite practically as ballast. It is, therefore, expected that the cost of production of alumina will be reduced below previous figures by the Hebburn works, because of the advantageous position and specialized plant employed.

The erection of the works, which occupy about one acre of a total ground area of close upon five acres, was begun on July 18, 1908, and its progress is being so vigorously pushed forward that in a very short time Tyneside alumina will be an accomplished fact.

The buildings consist of a furnace-house bay, 230 ft. long, together with two other bays of galvanized iron superstructures on a concrete foundation, devoted to the wet portion of the process.

A store is in process of erection, which will be capable of holding 2000 tons of bauxite and keeping it dry. The raw material is brought to this store by means of a full-gauge railway track, either from the North-Eastern Railway or from the closely adjacent River Tyne.

From the store the crude bauxite passes to the crushing house, where it is reduced to the fineness of flour. A motor-driven pneumatic separator plant both grinds and winnows the material at the rate of 40 tons per day; this plant was made by Messrs. Ernest Newell & Co., Ltd.

The ground material is then mixed with caustic soda, obtained from the neighboring works of the United Alkali Co., Ltd., and the mixture is lifted to a series of "kiers," or double-jacketed boilers, where the heat of steam in the outer jacket boils the liquid within. This arrangement is necessary to avoid dilution of the caustic soda.

After a number of hours' boiling it is blown into elevated tanks, and goes through an elaborate filtration process in a series of presses. The aluminate of soda which has been formed, being in a state of solution, passes through, while the suspended oxide of iron is rejected. A market for this by-product is now being developed, and this will constitute a further advance in the economical production of aluminium.

The aluminate of soda, after a second filtration, is brought up to such a state of purity that it is found in a subsequent stage that the amount of impurity in the hydrate of alumina is of the order of 0.001 per cent. After this filtration the aluminate of soda passes to a series of large tanks, each capable of treating upward of 45,000 gal. of liquid.

These tanks have large internal agitators electrically driven through two lines of shafting, seen in Fig. 5, and aluminium hydrate separates out and is drawn off to a third set of filters. The residue in the tanks, or "mother liquid," is the caustic soda, and so is the filtrate obtained from the third filtration.

The precipitate, however, is alumina in the form $Al_2O_3H_2O$. An electrically-driven air compressor blows air through this mass at a pressure of 8 lb. per square inch, and drives off the mechanically-contained water. The hydrate of alumina is calcined in the furnace house, a water-sealed gas producer being utilized to heat the furnaces, and the refined Al_2O_3 is then ready for transport to Wallsend or Dolgarrog.

It is, however, necessary to note the economical working of the plant as evidenced in the threatment of the caustic soda or mother liquid. This is passed back from the filters and large tanks to a series of evaporators for concentration, built by Messrs. Ernest Scott & Co., Ltd., of London. These consist of four large pans, 9 ft. in diameter, containing a series of tubes, through which the liquor passes and outside which steam plays.

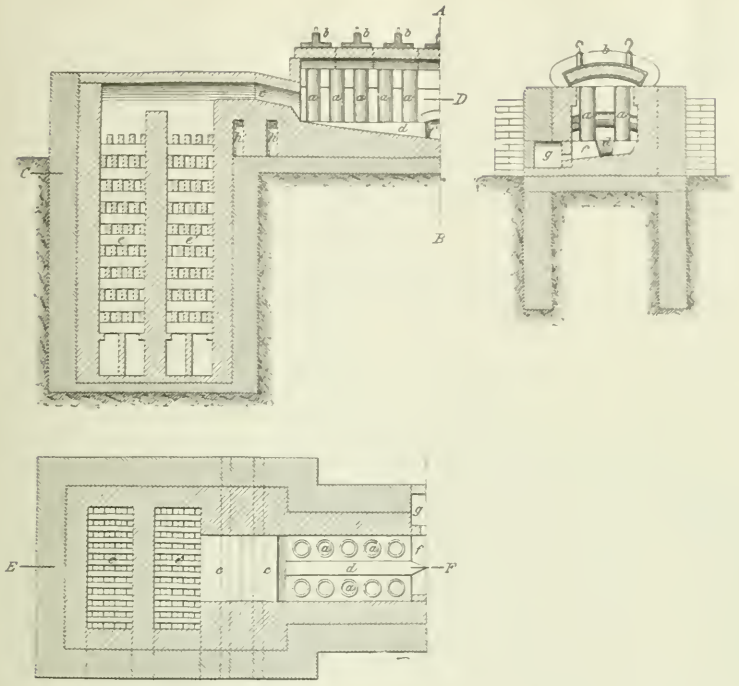
These are arranged so as to have a multiple effect. In the first pan exhaust steam at about 10-lb. pressure is used; the last of the series is subjected to a vacuum caused by a pump connected to a barometric condenser, and the vapor evolved from one pan boils the liquid in the pan next to it in such a way that it is possible to evaporate 2 lb. of water for every pound of steam originally used.

Moreover, the condensed water goes to feed the battery of boilers generating steam at 120 lb. per square inch for heating purposes and for generating electric power and lighting on the works. The heating is largely done by exhaust steam, the engines acting as a reducing valve.

Thus the Aluminium Corporation, Ltd., who hold five-sixths of the capital of the Bauxite Refining Co., Ltd., have caustic soda at their own doors; they have cheap coal, cheap electricity, cheap transit, and their own bauxite.

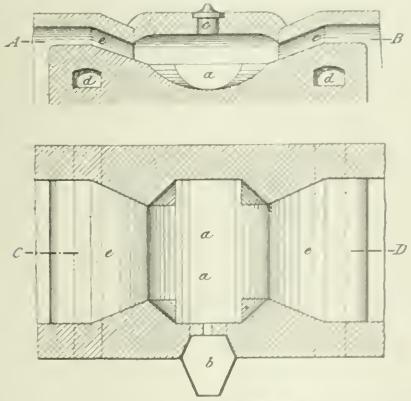
Kinlochleven Works.

As has been said before, the British Aluminium Co. is an old company. Its works at Foyers, with a capacity of 7500 hp,



FIGS. 1, 2, 3.—PRODUCER-GAS FURNACE FOR SMALL CASTINGS.

have been in operation since 1896. In spite of its name, the British Aluminium Co. also has works at Stangfjord, in Norway, and at Orsieres, in Switzerland, the total capacity of the various works being over 60,000 hp.



FIGS. 4 AND 5.—REVERBERATORY FURNACE FOR SMALL-SIZE METAL CASTINGS.

Their new British works are being erected at Kinlochleven in western Scotland. The hydraulic installation comprises nine large Pelton wheels, with an output of 3200 hp each, and two small turbines of 930 hp each.

The electric equipment comprises 20 main generators installed in all, each having an output of 1000 kw at a voltage of 250 to 275 volts. They are coupled in pairs to the water turbines. All the generators are of the direct-current multipolar type, with slot wound armature, and are shunt wound.

As in order to comply with the exigencies of the work, they have to run continuously at full load day and night for months at a time, it is necessary that all adjustments, renewal of brushes, and necessary cleaning and lubrication should be possible while the machines are running.

Each generator has a normal full-load output of 1000 kw when running at its normal speed of 300 r.p.m., but it is also capable of an overload output of 1100 kw for one hour, and can be altered to give any voltage, when self-excited, between 200 and 275 volts with any load from 0 to 1000 amp by adjusting the speed alone. The generators are designed to run continuously, when necessary, at the highest speed required, viz., 330 r.p.m.

The main switchboards are very simple in construction and have been equipped by the British Aluminium Co. themselves. Their most interesting feature is the extensive employment of aluminium in their manufacture. This metal has also been used for the busbars on the lighting and power and traction boards.

The production of aluminium at the permanent Kinlochleven works will be commenced early in 1909. A temporary factory at Kinlochleven has been in operation for the last year

The Use of Producer Gas in Chemical and Metallurgical Industries.

BY DR. OSKAR NAGEL.

While in Europe producer gas is widely employed in the chemical and metallurgical industries, in most of the American factories direct firing is still in use, although the advantages offered by producer gas are indisputable. The slow progress in the change from direct firing to gas firing in this country is possibly due to the fact that American manufacturers are not yet sufficiently familiar with the construction of producer-gas-fired furnaces suitable for their purposes. It may, therefore, be of interest to describe a few types of such furnaces which have been used successfully abroad for a good many years.

For small steel castings the furnace shown in Figs. 1 to 3 has proven an economical success. Fig. 1 is a vertical longitudinal section, Fig. 3 a vertical cross-section along line *A B* of Fig. 1, and Fig. 2 a horizontal section along lines *C D* of Fig. 1. These furnaces contain 20 crucibles and are built under ground up to the side of the hearth, so as to enable the operator to easily lift the arch covers *b b* and to get hold of the crucibles *a a* by means of suitable tongues. *e* is the air-regenerator, *e'* the gas regenerator. The steel runs off through *d*, is collected at *f* and discharged at *g*. *c* is the flue, *h h* the cooling channels, which are connected with the stack.

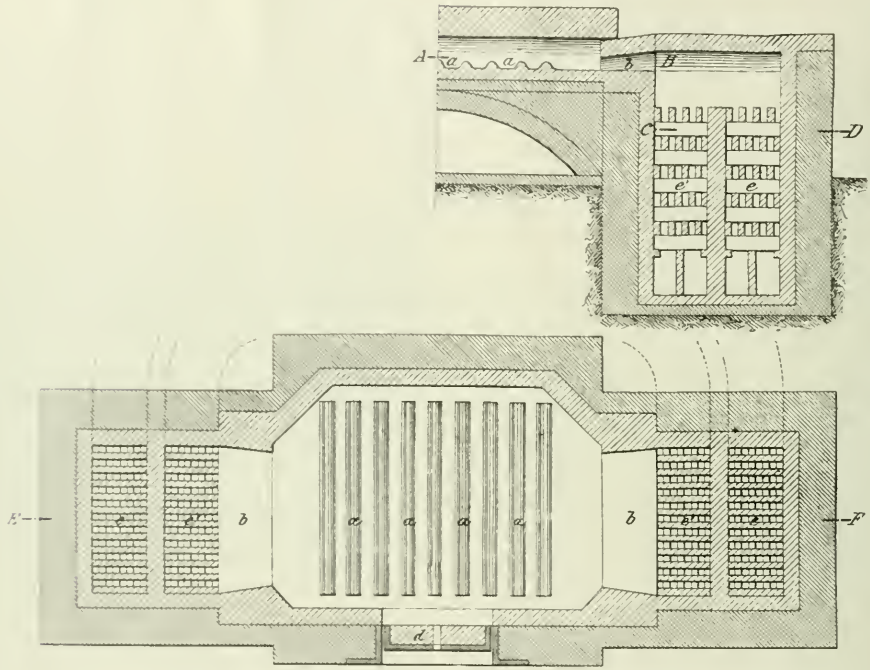
The life of the crucibles is as long as with direct firing; with

cast steel the operation takes about four hours and the hearth is to be renewed after every 52 operations.

A reverberatory furnace with regenerative gas firing for the manufacture of small-sized metal castings is shown in Fig. 4

This furnace is provided with a very low arch so as to keep the heat nearer the large area of the hearth. It is, of course, necessary to build these arches of sufficient strength.

By using producer gas in this furnace, the formation of



FIGS. 6 AND 7.—REGENERATIVE GAS FURNACE FOR HEATING COPPER PLATES.

vertical section along *C D*) and Fig. 5 (horizontal section along *A B*). *a* is the "crucible," made of best fire clay; *b* is the charging and discharging opening; *e e* are the flues; *d d* are the cooling channels, and *c* is an opening (which can be closed) for charging during the melting operation. The pieces

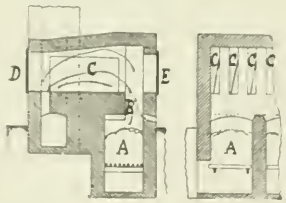


FIG. 8.—FURNACE FOR METAL SHEETS

of iron or metal can be somewhat preheated in the channels *d d*, which always get dark red at a welding heat. In shipyards these furnaces are very convenient for casting screws, etc.

A regenerative gas furnace for the heat treatment of copper is shown in sections in Figs. 6 and 7. The hearth is provided with corrugations *a a* for enabling the operator to conveniently get hold of the sheet metal. *b* is the flue, *e* the air regenerator, *e'* the gas regenerator, and *d* the working door, which is provided with a counterweight.

A copper plate of about 90 lb. gets red hot in 7 or 8 minutes and in 12 hours 3 to 3½ tons of sheet metal are rolled; the coal consumption is about 1½ tons.

oxide is much less than with direct firing. This means a higher economy, since the yield of metal is increased and the time of treatment is reduced as a result of the diminution of the quantity of oxide formed, which is a non-conductor of heat.

A furnace for heating sheet metal is shown in Fig. 8. It consists of the producer *A*, the combustion chamber *B*, where gas and air are mixed; the chambers *C*, which are separated by vertical walls and contain the charge, and the charging doors *D* and *E*. All chambers communicate at one end with the combustion space, and at the other end with the flue.

Fig. 9 shows a crucible furnace for 36 crucibles, constructed by Dawson, Robinson & Pope (Brightside Steel Works, in Sheffield). It is said to work very satisfactorily. (See p. 40.)

Notes on Electrochemistry and Metallurgy in Great Britain.

(From our Special Correspondent.)

Impact Tests of Iron and Steel.

Since the paper by Seaton and Jude before the Institution of Mechanical Engineers the feelings of metallurgists upon impact testing have undergone a change. In the first instance, their views as to the efficiency of the test were enthusiastically received; but in course of time a school led by Mr. Harbord began to express dissatisfaction and doubt as to the general reliability of the method. This dissent has culminated in a discussion before the Institution of Mechanical Engineers upon two papers concerning this subject, the first by Dr. T. E. Stan-

TON and Mr. L. BAIRSTOW dealing with "The Resistance of Materials to Impact," and the second by Mr. F. W. HARBORD treating of "Different Methods of Impact Test on Notched Bars."

Dr. Stanton, in introducing the first paper, said that in first object primarily concerns the steel maker, who wishes to avoid supplying dangerous material; and the second concerns the engineer or designer. The detection of brittleness is obviously best accomplished by a single-blow test, and the proper means of determining resistance under working conditions ap-

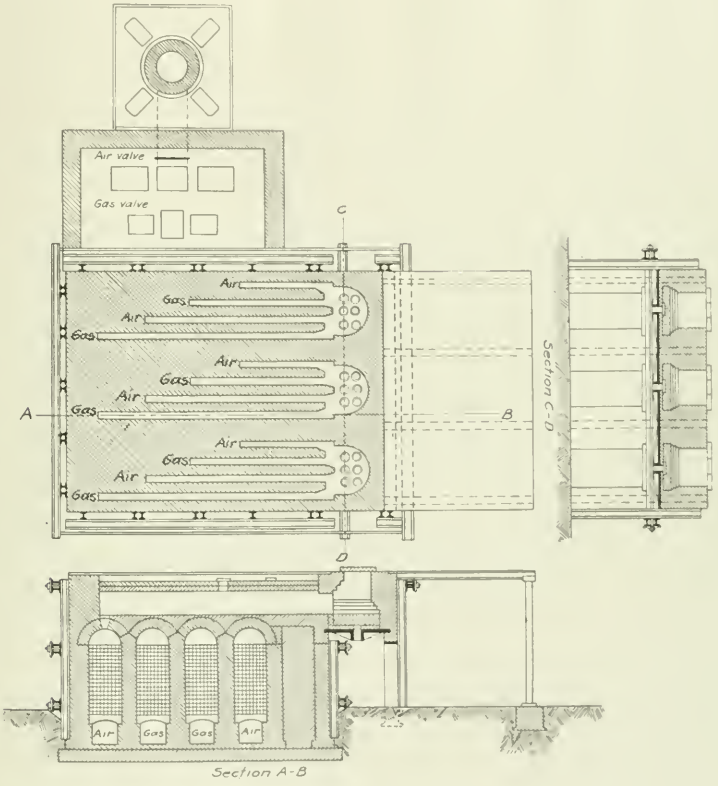


FIG. 9.—CRUCIBLE FURNACE.

ordinary machine practice the stresses induced in moving parts were in general due to a combination of shock and gradually applied load. He and his fellow-author had already investigated the effects of reversals of direct stress, and it was thought that the determination of the effects on the same materials to sudden shock would be of value to the designer. Such a research was urgently called for since the proof resilience of a material—the *maximum* work which could be stored up per unit volume without permanently deforming it, as calculated from statical experiments—was quite unreliable as an index of "useful toughness."

As in the research on alternating stresses, the machines were designed for endurance tests up to one million shocks or more. These machines lent themselves equally well to the fracture of specimens under comparatively few blows; and the authors were led to the comparison of the result of impact tests, which consisted of a large number of small blows, with those consisting of a small number of heavier blows or even of a single blow to destruction.

An impact test may be made for one of two objects: (1) to ascertain if the material is brittle, or (2) to determine the resistance to shock under working conditions of the material relative to the resistance of other well-known materials. The pears to be a "shock-fatigue" test by a large number of small blows. Full descriptions of the machines employed were given, as well as particulars of the materials tested, which included Swedish charcoal iron, commercial and Swedish Bessemer steels, best English wrought iron, and boiler plates. The authors found that there is no source of weakness brought out by single-blow impact tests on plain or notched specimens which is not revealed by a careful static test.

The general conclusions are that for the detection of two important faults, brittleness and low elastic resistance, two distinct tests were necessary according as weakness in plastic resistance or inelastic resistance is to be revealed. Conclusive evidence was shown that materials which were strong under alternating stresses were generally strong under those shocks likely to be put upon them in ordinary machine practice, and not weaker as seems to be commonly supposed. The authors were unable to agree with Messrs. Seaton and Jude that the common interpretation of resilience had failed in its practical application; but, on the contrary, believe it to be the best guide for the designer in the use of normal materials of which the real elastic limits are known.

The experiments further showed that steel is a much more homogeneous material than it was recently suspected to be.

changes in microstructure due to impact and to fatigue [illegible] with and illustrated by photographs.

* * *

Mr Harbord said that the experiments recorded in his paper were undertaken to compare the results obtained by different methods of impact testing and also to see whether such tests detected any irregularity in steel not revealed by ordinary tensile tests, and to what extent they were in agreement with the latter.

All steels used by engineers for structural and railway work were represented, and tensile tests of all the steels and hardness tests by the Brinell method were included. Five different methods of impact testing were employed, viz., those of Seaton, and Jude, Fremont, Izod, Brinell, and Kirkaldy; and over 40 different steels were experimented with.

Duplicate tests of the same material by each method for untreated steels showed that variation for the softest steels was greatest in the Kirkaldy horizontal method. With the second hardest steel Izod gave much the greatest variation, and both the Kirkaldy methods much the least. With the highest carbon steels Seaton and Jude, Fremond, and Izod all give most irregular results, and the Kirkaldy methods—both horizontal and vertical—alone give any approach to regularity. In the case of overheated soft steels (0.20 per cent carbon) this superiority is maintained; but with high-carbon steels and restored steels the Izod method appears to furnish the most uniformly consistent results. The author considers that the irregularity disclosed by the different methods of impact testing is not due to lack of uniformity in the material, but largely, at all events, results from the defects of the method of testing; and it is a serious question how far methods showing such variations should be relied on by engineers to differentiate between the physical properties of different materials.

The Arnold alternating tests show very little variation between the duplicate tests, although, like the tensile tests, they show that the overheated bars are more ductile than the restored.

With the exceptions of the steels below 0.2 per cent of carbon, all the commercial steels would be condemned by the Fremont method, as they all break below 100 foot pounds. Not only were the tensile tests of these steels satisfactory, but they were good average samples of commercial steels from first-class firms. If we have to accept these impact tests as true indications of the quality of the material, we not only have to accept results in entire disagreement with the tensile tests, but entirely at variance with general experience.

Sir Robert Hadfield said that many of the troubles of the steel maker might have been reduced had the knowledge given by the investigation of impact tests been available at an earlier date. In the light given by Dr. Stanton's researches, the failures which had occurred in service were not surprising. It would appear that if impact testing were properly carried out the necessity for tensile tests would be largely reduced, and he agreed with the statement that impact testing by the single-blow method was likely to afford all the information which the steel maker and engineer required for the selection of the material best suited for endurance of shock. At the same time he did not suggest the abandonment of tensile tests. A branch of research which might yield valuable results was the study of tests at high temperatures, and he was himself carrying out tests in that field at Sheffield which he hoped might lead to some useful results. Mr V. Jude suggested that Mr. Harbord's results were broadly identified with variations in structure and were not due to the methods employed. Mr. Michael Longridge agreed with Dr. Stanton's view of the value of impact tests. It seemed to him, however, that the repeated application of small blows rather than a single blow-test was more likely to realise the conditions of service and to give a reliable test. Mr. Bertram Blount, who had on exhibition in the hall a machine for impact testing, designed in conjunction with Captain Sankey, said he had carried out satisfactory tests with the machine, which consists essentially of a vertical rod, which is a guide for a falling weight, the specimen being held in a suitable clamp.

The Institute of Metals.

At the first general meeting of the Institute of Metals at Birmingham, which took place on Wednesday, Nov. 11, the president, Sir William White, explained the objects of the society. In the course of his remarks he dealt with the reasons which had led to the establishment of the institute, and described it as another step in the direction of inevitable specialization. Its founders were confident its existence would be justified by its work; it was intended to promote community of interest and information, and it was also intended to promote free communication between the metal trades and users of non-ferrous metals. As regarding the latter class, he ventured to assert that no less importance attached to the interchange of information between manufacturers. No one could doubt that frank conference and discussion, such as the institute would encourage, might lead to a reconsideration of many conclusions hitherto regarded as definite and final. At present many difficulties and failures which occurred in the use of metals arose from causes that remained obscure and demanded thorough investigation. He was sanguine enough to believe that the establishment of the institute would promote the growth of the scientific spirit and in the end would lead to better conditions, to freer and more cordial intercourse, to united effort for improvement on the part of makers and users, and to the universal conviction that all classes must be benefited by encouragement of research and the freest publication of results obtained which circumstances might permit. If they were to succeed in that endeavor, the proceedings of the institute must embrace contributions from and discussions between users and makers of non-ferrous metals and their alloys. The cordial collaboration of members of the institute whose interest in metals was chiefly of a scientific character was one of the most important guarantees of their success. The range and variety of possible researches into the properties of non-ferrous metals and their alloys are so great that there is scope for all classes of investigators.

The Castner-Kellner Alkali Co.

The position of the Castner-Kellner Alkali Co. (Ltd.) remains eminently satisfactory. The net profit for the year ended Sept. 30, after the usual expenditure in keeping up works, plant and machinery to the highest state of efficiency, is £115,528 3 9, which with £14,420 9 4 from 1907 made £129,948 13 1. Interest required £9,443 2 7, and interim dividend at the rate of 10 per cent for the six months to March 31, £22,500, and the available balance is £98,005 10 6. The directors are putting £30,000 to depreciation reserve, writing £5,000 off suspense account and £1,386 off plant accounts, placing £12,500 to general reserve, appropriating £33,750 in payment of a final dividend of 1s. 6d. per share (making 12½ per cent for the year), and leaving £15,369 10 6 to be carried forward.

The Thermit Process.

Mr. R. Stütz, managing director of Thermit (Limited), London, delivered a lecture before the members of the Sheffield Society of Engineers and Metallurgists on Monday, Nov. 16, on "The Aluminothermic Process." He described the composition of this heat producer. The principle underlying the process is the affinity which aluminium has for oxygen. In a mixture of aluminium and iron oxide, for instance, the aluminium will combine with the oxygen in the oxide, and set free the pure liquid iron at a temperature of about 5400° Fahr. Dealing with thermit welding, he showed that iron in a very fluid state is produced and runs into the open spaces left for it in the mould. The main advantages of thermit process for the welding of tram rails were the obviating of loose joints and knocking noises. There was also an enormous saving in

the repair and maintenance of the permanent way, as well as a lengthening of the life of the rail. Taking the life of a rail as 12 years, the annual cost of repairs and maintenance, after the first five years, might on an average be taken at £150 per mile, or if welded joints were used, a saving of £75 per mile per annum for seven years. At the present time most of the rails which required renewing were only about two-thirds worn out, except at the joints, owing to the impossibility of keeping the rail ends tight and level, as the result of the poor support given by the customary method of joining. The initial cost of the joints, based on 60-ft. rails, was only about £30 to £40 per mile in excess of ordinary joints. The welded joint also secured perfect and permanent electric conductivity without the use of copper bonds, which generally after a few years' service became less efficient. This method of welding tram lines had now been used in about 50 different towns in this country alone.

Metallic-Filament Lamps.

The impetus to the lighting industry natural at this time of year has served to emphasize the tendency toward flame arcs and metallic-filament lamps in electric lighting. Figures of comparative burning of osram and tantalum incandescents are available in a case where 168 of the former and 848 of the latter are installed, making a total of 1016. At the end of 1200 hours, 84 of the original osram and 285 of the original tantalum lamps were still in use, i. e., 50 per cent of the original osram lamps and 33 1/3 per cent of the original tantalum lamps were still in working order. The former lamps cost 2s. 11½d. each and the latter 1s. 10¼d. each, so that the difference in the actual cost of renewals when the average life is considered is but slight, while the consumption of the tantalum lamp is 40 watts and of the osram lamp 28 watts for equivalent candle-power.

The Weighing of Ore Cargoes.

The British Vice-Consul at Rio Marino reports that the Italian government has introduced a practical method of weighing cargoes of iron ore. The ore from the mines being transported exclusively by water, it has been possible to lay down rules for loading vessels by the "Provini" test tube areometer system under government inspection. This system consists of a pair of brass tubes affixed to either side of the vessel at one-third of her length between the deck and the hold. A graduated scale of measurements in tons and hundredweights is attached to a floater at the water line. Upon operations commencing, the lids of these tubes are removed and the scale rises automatically, marking first the stores, etc., which form no part of the cargo. As the latter is stowed, the scale rises. The weight loaded can thus instantly be ascertained; for example, fore part of ship, 127 tons 4 cwt., and aft, 136 tons 6 cwt., equals 263 tons 10 cwt. Deduct 4 tons 6 cwt. stores, the net weight put on board will be 259 tons 4 cwt.

SYNOPSIS OF PERIODICAL LITERATURE.

Iron and Steel.

Rusting of Iron.—The Materialsprüfungsamt of Gross Lichterfelde has recently issued a most exhaustive treatise on the influence of water and aqueous solutions on the rusting of iron. The work comprises some 104 pages of text and 148 illustrations, and was carried out under the direction of Prof. E. Heyn and O. Bauer. A brief abstract appears in *Stahl und Eisen*, Oct. 28. The rôle played by CO_2 furnishes the foundation for a series of experiments the results of which are summated as follows: 1. Iron will rust under conditions in which CO_2 is absolutely absent. 2. Air containing 15 per cent CO_2 under the same conditions is only twice as active as air absolutely free from CO_2. It is not likely or possible that the small amount present in the atmosphere exerts any action on the process of rusting. 3. The degree of attack is dependent on the manner of introducing oxygen (bubbling of air, exposure to diffusing air, etc.). The introduction of oxygen by bubbling air through the solution is about twice as active in promoting rust as the simple contact of the surface of the liquid with the air. 4. The rusting is dependent on the partial pressure of the oxygen in the atmosphere above the liquid immersing the sample. In an atmosphere of pure oxygen the attack is three times as strong as in ordinary air. Pure CO_2 causes no peculiar rusting. It acts as any acid by dissolving with the evolution of hydrogen. True rust only appears on the introduction of oxygen. Free oxygen is necessary for rusting, the presence of the oxygen combining with hydrogen as water playing no part in the action. Iron is an extraordinary sensitive reagent for the determination of oxygen dissolved in water. It is not, however, available for quantitative determination because the loss of weight of the iron is partly due to oxide in each of the two states, the proportion of ferrous and ferric not being constant. Rusting may be prevented by removal of oxygen from water. Evacuation and boiling are not technically possible in most cases. Even when removed a coating of oil will not prevent reabsorption of air. With this knowledge of corrosion it may be said that the velocity of rusting is proportional to the distance of the metal from the surface of the liquid in contact with the atmosphere; to the area of this surface of contact; to the rate at which oxygen is bubbled through the solution; to the partial pressure of the oxygen in the atmosphere above the liquid; to the rate at which the fluid in which the iron is placed is renewed; to the proportion between the surface of the iron and the volume of the liquid it is in; a mathematical discussion is given of these ratios. The action of hydrogen peroxide in various concentrations allowed of no particular conclusions being drawn. In regard to the attack of the metal of gas holders where the same came in contact with the water in the well, it was believed that the illuminating gas retarded corrosion.

In general, it was proven that iron rusts less and the other metals more when placed in contact with a metal lower in the e.m.f. series than the iron when placed in a solution which ordinarily rusts iron. The opposite is true when in contact with a metal above itself in the series. A sample of iron in contact with copper rusted 25 per cent more in the tap water of Charlottenburg, and 47 per cent more in artificial sea water, than when placed in these two solutions alone. Contact with nickel increased the attack on the iron 14 to 19 per cent. Cast iron in contact with wrought iron protects the wrought iron at its own expense. The wrought iron showed 28 per cent less corrosion in a solution through which air was bubbled, and 50 per cent less in a solution in contact with quiet air. In general, it was found that iron in contact with identical metal mechanically treated in various ways showed a difference in potential between the various samples. When overheated and non-overheated metal are placed in contact in water, the non-overheated metal is more strongly rusted than when placed therein alone.

The third part of the investigation is concerned with the rate of attack on various kinds of irons, details of analysis, etc., being given in the original. In the case of cast irons no conclusions could be drawn on the effect of the various ingredients in the metal. A series of experiments was also carried out on the attack of various liquids on the iron at room temperature. The data is essentially given in form of curves. Chromic acid and potassium iodate seem to have a critical concentration above which there is no attack, magnesium nitrate, sodium nitrate, and sodium sulphate showing the same phenomenon at considerably higher concentrations. It was not proven that sodium carbonate and other alkaline solutions protected from rust, or that sodium and potassium chloride or sulphates accelerated corrosion, as is commonly believed. Chromic acid and potassium chromate are the best protections against rusting. The final portion of the paper is concerned with the

measurements of the potential of iron against various fluids as measured with the normal electrode

Cupolas.—Bernhard Osann gives some dimensions of foundry cupolas in *Stahl und Eisen* for Oct. 7. From a general consideration of the best working foreign cupolas they are found to average a section at tuyeres of 1100 sq. cm. (175 sq. in.) per ton of output per hour. American practice is 1050 sq. cm. (200 sq. in.) The section of the cupola should markedly contract toward the tuyere section. A formula for the calculation of the pressure of the blast is $H = 50\,V\,Q$, where H is the pressure of the blast in centimeters of water and Q the volume of air supplied per second. Q should be proportioned to give the largest possible proportion of CO_2 in the gas. The total area of the tuyeres should be one-fourth to one-fifth of the area of the tuyere section. Under these conditions the coke consumption will vary between 9 and 11 per cent of the weight of the iron melted. The limestone addition varies greatly in the different plants, from 27 to 40 per cent of the coke charged.

Iron-Silicon-Carbon Alloys.—In *Zeitschrift für anæorganische Chemie*, W. Gonterman reviews the iron-silicon-carbon alloys. In regard to the binary systems which contribute to this equilibrium, an iron containing 0.07 per cent carbon showed consistently a halting point on cooling curve at 1411°, in addition to the usual ones at 852° and 770°. This is designated as a questionable transition point. In the system iron-carbon the well known compound Fe_3C is thought to fuse to two immiscible liquids, one rich in iron and one rich in graphite. An elaborate discussion, with diagrams, supports this. On cooling the liquid mixture, cementite first crystallizes from each phase. On further cooling, cementite from the iron-rich melt crystallizes with graphite as an entectic. At 1100° (a temperature below the entectic) non-variant equilibrium between cementite, martensite and graphite occurs, owing to changes in stability between cementite and graphite. Below 1100° two sets of conditions are determined by the temperature: (1) absolutely stable system, the solubility of grahpite in iron decreases with fall in temperature and separates from the corresponding phase, martensite. (2) Unstable system—graphite formation is prevented and martensite suffers transformation into cementite and ferrite. This gives a satisfactory explanation of the formation of kish in alloys containing over 5 per cent carbon, this superficial graphite corresponding to crystallization of the upper graphite rich layer.

The ternary system was studied within the limits $Fe - Fe_3C - Fe\,Si$. A curve of monovariant equilibrium divides this region into two sections, the curve joining the binary entectic points Fe — C and Fe — Si. In the region between this curve and the curve joining the concentrations of the two compounds Fe_3C and $Fe\,Si$ there occurs primary crystallization of "mixed crystals" (silicon-cementites) and secondary crystallization of a mixture of this variety of mixed cystals with another ternary variety. This latter variety of mixed crystals may be regarded as martensite containing silicon. Their crystallization surface lies above the region between the previously mentioned curve of monovariant equilibrium and the pure iron point. The curve joining the two points which give the saturation concentrations of binary mixed crystals in the respective systems Fe — C and Fe — Si shows the silicon and carbon contents of the saturated silicon-martensites. Melts, the concentrations of which lie between the curve of saturated silicon-martensite and the iron point, on cooling separate out unsaturated silicon-martensites. Melts whose concentration lie between the curve of saturated silicon-martensites and the first mentioned curve of monovariant equilibrium form primary crystals of saturated silicon-martensites, concluding the solidification by forming secondary crystals of saturated silicon-martensites and silicon-cementites. Analogy between the binary system iron-carbon and the ternary system iron-carbon-silicon can be discerned. It is particularly preserved in the polymorphic transformation. In the ternary system, as in the binary system, either a formation of graphite or a transformation of the primary mixed crystals to constituent metal and compound is marked by a continued fall in temperature.

Chromium and Manganese Alloys.—G. Hindrichs in the same journal also records an elaborate series of investigations on the chromium and manganese alloys, the results of which he summarizes in the following table:

Alloy.	Gap in miscibility. Liquid phase.	Gap in miscibility. Crystalline phase.	Compounds.
Sn-Cr	0·87% Cr	0·95% Cr	None
Pb-Cr	10·75% Cr	0·100% Cr	"
Cu-Cr	2·98% Cr	0·100% Cr	"
Ag-Cr	0·92% Cr	0·100% Cr	"
Al-Cr	0·36% Cr	0·85% Cr	$AlCr_3$ (?)
Al-Mn	14·42% Mn	0·62% Mn	Al_3Mn (?), $AlMn_3$ (?)
Ag-Mn	2·87% Mn	0·100% Mn	None

Fusion diagrams are given in all the above cases.

Coke.

Analysis.—An investigation of the great discrepancy which existed between laboratory tests and actual practice in the coke output of bituminous coals was carried out by F. W. Hinrichsen and S. Taczak at the Königliche Materialprüngsamt, Gross Lichterfelde. The following new method of proximate analysis was determined upon: Four to 5 grams of finely pulverized coal is placed in a Rose crucible of 40 cc to 50 cc capacity; diameter at bottom, 20 mm; height, 50 mm; top diameter, 50 mm. Hydrogen is introduced through the tube for 10 minutes, then it is heated for two minutes with moderate bottom flame, then for five minutes with bottom flame and two side flames, or the heating is continued until the yellow flame disappears, using the three burners. It is cooled in the current of hydrogen. Determinations made by this method usually show several per cent higher coke output than the older methods and agree very well with practice. In a set of comparative determinations made with the two "Muck" methods and this one, the results derived in practice were a shade lower than the experimental determination in hydrogen, and several per cent nearer than the "Muck" determinations.

Smelter Fumes.

Injury to Vegetation and Animal Life by Smelter Wastes.—This is the subject of an interesting contribution of Mr. J. K. Haywood in Bulletin 113, Bur. Chem., United States Department of Agriculture. This is a report of the work done in and around Anaconda, Mont., to determine the effect upon vegetation and animals of the several wastes from the reduction of ores as practiced in that locality. The wastes are classified as (1) sulphur dioxide, given off and allowed to escape in the atmosphere during the process of smelting; (2) the volatile arsenic given off in the smelter fumes; (3) flue dust from smelter stacks containing fine particles of copper, lead and zinc; (4) the leachings from tailings which are allowed to run into streams, the water being used later for irrigating purposes.

A report is also made of an experimental study of the effect upon vegetation by sulphur dioxide, and the resisting power of numerous plants to the injurious effect of this gas, together with methods of analysis used in the investigations. As a result of the investigations, the author concludes that: The forests around the smelter appear from actual chemical analysis to be injured for at least 10 miles north of the smelter; 6 miles south of the smelter and 13 miles west of the smelter. This injury to forests by sulphur dioxide undoubtedly extends to a distance of 15 to 20 miles north of the smelter, 8 miles south of the smelter and 15 miles west of the smelter, and perhaps even farther in certain localities, although not proved by chemical analysis. The junipers are very resistant to smelter fumes and are able to grow close to the smelter; the red firs are susceptible to the fumes and are badly damaged at distances of about 15 miles, or perhaps even farther; the lodgepole pines are intermediate between the other two species of trees, but show damage for at least 10 miles. Large quantities of arsenic are discharged from the smelter on the surrounding country, this poison being found in forage crops in large enough quantities to poison cattle. The waste from the reduction plant dis-

charged into the Deer Lodge River renders it unfit for irrigation purposes. The land irrigated by the Deer Lodge River, containing the waste from the reduction plant, is greatly injured by the copper present in the irrigation water. The soils irrigated by the Deer Lodge River, which were studied by the writer, do not contain enough alkali salts to be injurious to ordinary farm crops.

This Bulletin recalls the work which appeared in the *Journal* of the American Chemical Society in June of this year. The first paper on "Arsenic in Vegetation Exposed to Smelter Smoke," by R. E. Swain and W. D. Harkins, was concerned with the vegetation of the Deer Lodge Valley, near Anaconda, Mont. Many samples of grass and hay were examined, the largest amount of arsenic as As_2O_3 found was 1551 parts per million. The authors believe that the evidence produced warrants the conclusion that the arsenic is not absorbed from the soil, but is deposited from the smelter fumes.

The second paper, by W. D. Harkins and R. E. Swain, on the "Chronic Arsenical Poisoning of Herbivorous Animals," describes the poisoning of animals by arsenic in the vicinity of Anaconda, Mont. Autopsies of a large number of animals were made and many samples analyzed showing arsenic in considerable quantities in the body tissues. A number of grasses and hays were examined and large amounts of arsenic found, in some cases as much as 155 parts of As 203 per million.

Thorium.

Chloride.—Dr. Werner von Bolton contributes to the Nov. 20 number of *Zeitschrift fur Electrochemie* an interesting article on thorium. He prepares thorium chloride by heating thorium oxide to bright redness in a glass tube and passes over it carbon tetrachloride, the reaction being $ThO_2 + CCl_4 = ThCl_4 + CO_2$. By placing this chloride in an iron crucible in alternate layers with sodium, covering with calcium chloride and heating, he received within 4 per cent of the theoretical output of the metal, calculated on the oxide used. The metal obtained consisted of a felt-like mass of crystals. By packing these crystals in a copper tube and passing the whole through rolls and subsequently dissolving off the copper envelope in nitric acid, a wire of pure thorium could be made. This wire could be rolled out into a ribbon if desired. Heated to 1450° in a vacuum the wire could be fused to a homogeneous whole. The color, hardness and ductility of the metal correspond to those properties of platinum. The density of the powder was found to be 11.32; of the rolled and heated wire, 12.16. Boiling caustic potash or nitric acid do not attack the metal; sulphuric acid slightly; hydrochloric acid, easily. A compound of thorium which does not have the properties of the ordinary thorium compound has been called by the author muriaticum-thorium. It is made by dissolving pulverized thorium in 5 per cent hydrochloric acid. After filtering from the part of the metal which does not go into solution, it can be precipitated by heating. It is soluble in water, dilute hydrochloric acid, not in concentrated hydrochloric acid. It does not precipitate silver from silver solutions. Its formula has been determined as $(ThO_2)_{16}.(HCl)_4$. A complete table of comparative qualitative properties of normal chloride and muriaticum is given in the original. No difference was found in the radio-active properties of the two compounds.

Units and Constants.

The Committee on Definitions and Units, representing a number of German technical and scientific societies (among them the German Bunsen Society), has recently published a new set of definitions and units in reference to electrical and mechanical branches. Definitions are given of potential, potential differences, electric tension, electromotive force, etc. The reciprocal of the resistance is called the conductance; the unit is called the Siemens, designated by S (that is, what we call mhos in this country). This reciprocal of resistivity or specific resistance is called conductivity or specific conductance.

The following values of the mechanical equivalents of heat are given.

The mechanical equivalent of the 15° gram calorie is 4.189×10^7 ergs, or 4.189 joules.

The mechanical equivalent of the average calorie (0 to 100°) is the same as that of the 15° calorie.

The numerical value of the constant R of the gas law $pv = RT$ is $R = 0.8310 \times 10^8$ when pv or RT is given in ergs or $R = 8.310$ when pv is given in joules, or $R = 1.985$ when pv is given in gram calories.

The constant of Joule's law is 0.2387 (1 joule or watt second = 0.2387 gram calorie).

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Treatment of Aluminium Silicate.—A [illegible] patents on the treatment of aluminium silicate in the electric furnace have been granted to Mr. Frank J. Tone, superintendent of the Carborundum Co. Aluminium silicate is an ore of wide occurrence and is the basis of all true clays. Kaolin is mixed with carbon so as to reduce the silicon, but not the aluminium, i. e., about 222 parts of ore to 48 parts of carbon. Treatment in an electric arc furnace yields the reaction

$$Al_2O_3.2SiO_2 + 4C = Al_2O_3 + 2Si + 4CO.$$

The products are, therefore, alumina and silicon. The fused alumina tends to settle to the bottom of the furnace. (906,338, Dec. 8, 1908.)

The reduction of the silicon by the above reaction is facilitated by adding to the charge base metal or ore, such as iron or manganese, which alloys with the silicon and makes the reduction of the latter more complete. For instance, 222 parts of calcined kaolin may be mixed with 48 carbon and 56 iron. Then the reaction in the arc furnace is

$$Al_2O_3.2SiO_2 + 4C + Fe = Al_2O_3 + FeSi_2 + 4CO.$$

The iron silicide being heavier than the alumina has a tendency to settle to the bottom, from which it may be tapped at intervals during the run. It also agglomerates in nodules of greater or less size throughout the finished product. After the ingot has cooled, it is broken up and the silicide is separated from the alumina, for instance, first by hand separation and then by crushing and some mechanical method of concentration. By adding manganese or manganese ore in the proportions to form a silicide containing 45 to 50 per cent manganese, the alloy is very friable and on exposure to air tends to disintegrate into a fine powder. An iron silicide containing 35 per cent iron is of similar character. (906,172, Dec. 8, 1908.)

By using less carbon in the charge than corresponds to the above reactions, not all the silicon is reduced. For instance,

$$2(Al_2O_3.2SiO_2) + 6C = 2Al_2O_3 + SiO_2 + 6CO + 3Si.$$

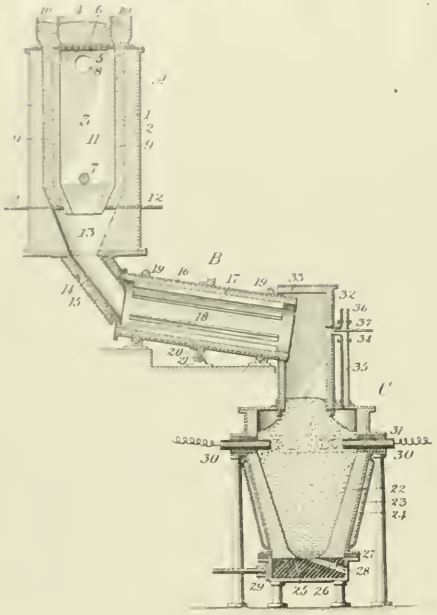
In this case a mixture of 77 per cent alumina and 23 per cent silica is produced in form of a homogeneous material of great hardness and with valuable abrasive and refractory qualities. Of course, in this case iron may also be added to the charge, in order to obtain the silicon in form of ferrosilicon. By further varying the amount of carbon in the charge, the percentage composition of the alumina-silica mixture may be still further varied. (906,174, Dec. 8, 1908.)

The fused aluminum-silica material has a hardness equal to that of many grades of corundum and is very tough. It is, therefore, valuable as an abrasive. It may also be used as a refractory. When it is tapped from the furnace, it may be cast into molds. Its hardness and toughness may be varied by varying the ratio of silica and alumina, and these valuable qualities are produced by the use of the carbon, which carries between 3 and 25 per cent. (906,338, Dec. 8, 1908.)

Tantalum.—[illegible] Siemens & Halske A. G., process for

...ar and sends an electric ... alic tantalum electrodes ... recess is carried ... The fused body thus ... and has such a high degree of ... be rolled into very fine sheets and drawn ... (904,831, Nov. 24, 1908.)

Calcium Carbide.—M... L. Price, general manager of the ... Co., has patented a calcium carbide furnace, ... The chief feature being the method of pre-



... ARBIDE FURNACE.

... and feeding the charge. The preheating apparatus *A* ... rectangular tower 1 of firebrick, enclosing the lime chamber 3. The lime and carbon are charged separately. The lime ... from the hopper 4 and through the inner chamber 3 ... fore it a shower and is thereby heated by the hot products ... combustion rising upward from the burners 7 and escaping ... through 8. The carbon is fed from the hopper 10 and moves ... downward through the passages 9 in the wall of the tower. ... prepared materials pass into the revolving cylinder *B* ... acts as mixer and then into the electric furnace *C*, in ... the bottom 25 is a resistor, the bottom of solid carbon ... and the side and carbon rods 30, arranged radially ... top, as the other electrodes. Molten calcium carbide col... ... the bottom and is tapped through 28. A burner 34 ... chamber 32 opposite the end of the mixer and is ... waste carbon monoxid from the furnace through the ... pipe 35, while air is supplied by pipe 37. In this way a high ... is maintained in the mixer. (904,991, Nov. 24, 1908.)

Metals and Alloys Free from Carbon.—A recent patent ... like others of the same inventor noticed be... relates to the use of silicon as a reduc... for production of pure metals ... from their ores. In the present case car... silicide is used as reducing agent, and the ... furnace is ... as follows. As the chrom... ... consists of chromium sesquioxid, Cr_2O_3, and practically all the iron as ferrous oxide, FeO, the following reactions take place:

$$Cr_2O_3 + SiC = 2\,Cr + SiO_2 + CO.$$
$$3\,FeO + SiC = 3\,Fe + SiO_2 + CO.$$

A fair commercial grade of chromite contains 25 per cent Cr_2O_3 and 16 per cent FeO, and 100 lb. of this ore will, therefore, require, according to the above reactions, about 16.6 lb. of SiC for complete reduction of the chromium and iron. It is advantageous to use the silicide of carbon and chromite in a fairly fine state of subdivision, depending on the scale of the operation. The use of a basic flux, such as lime, is usually advantageous as tending to economy of operation. By mixture in practically theoretical proportions a high yield of chromium and iron is obtained. If it is important to get a very low silicon content in the alloy (less than 0.2 per cent), the chromite is used in slight excess. The process is carried out continuously in an electric furnace in which the current passes through a molten bath of a mixture of ore, silicide of carbon and flux, and from which part or all of the metal or slag may be withdrawn as desired, fresh portions of the mixture being added from time to time. Since the reaction between carbon silicide and the oxides is exothermic, a relatively small amount of electrical energy is required. The materials should be used in a finely subdivided state and well mixed.

Electrolytic Processes.

Bleaching Liquor.—A. Vogelsang patents details of construction of an electrolytic apparatus for producing hypochlorites or bleaching liquor from aqueous solutions of rock-salt. In his cell the liquid used as an electrolyte is cooled down

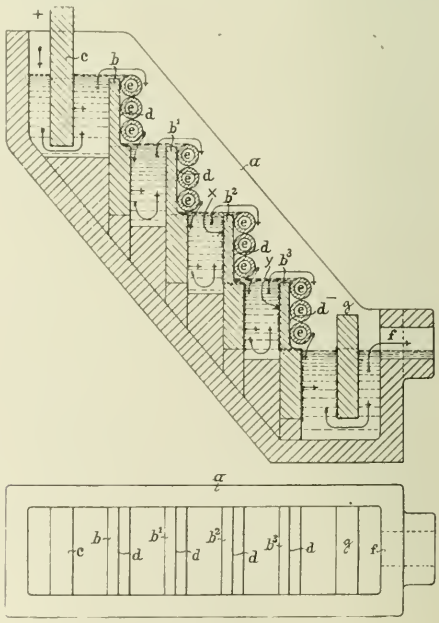


FIG. 2.—BLEACHING LIQUOR CELL.

during its overflow from one compartment to the next one either by its contact with the atmospheric air or by suitable cooling tubes or by both, in such a manner as to obtain a thorough or intimate mixing of the electrolyte within the compartments and obviating an increase of the temperature in the same. For this purpose the electrodes, arranged in the form of partitions, are provided in step-like formation within a slanting vessel. One of the electrodes forming a wall of one compart-

ment is continued or projected above the bottom of the vessel in such a manner that its projecting part forms the wall of the compartment next above. In this manner, a non-electrolytically acting surface is formed on one side of the partition over which the electrolyte will flow down in a thin layer on its passage from one compartment to the next one and will thereby be cooled. The cooled electrolyte falls down within the compartment on one partition of the electrode and rises on the other partition, so that a constant circulation within the compartment is secured and a heating of the electrolyte is obviated. The electric current selects that path which offers the least resistance and, therefore, very little current will pass through the thin part of overflowing solution, as the current passes chiefly through the electrode from one side to the other. In Fig. 2 b, b^1, b^2 are the electrodes of graphite or platinum, acting as bipolar electrodes. Thus, the lower part of the right-hand surface of b acts as anode, and the upper part of left-hand surface of b^1 as cathode in the same compartment. The upper parts of the right-hand surfaces of b, b^1, b^2, all being marked d are non-conducting surfaces of glass, slate, etc., e are cooling pipes, c is the anode at one end and g the cathode at the other end. The path of the solution through the cell is indicated by arrows. (906,669, Dec. 15, 1908.)

Ornamental or Protective Coatings for Platings.—E. C. Broadwell recommends for ornamental or protective coatings the use of a readily soluble sulphonate, preferably the naphthalene disulphonate, as electrolyte. For plating with zinc he uses a solution of zinc sulphate with zinc naphthalene disulphonate. For brightening the deposits, a small percentage of aluminium sulphate is added to the latter solution. (905,837, Dec. 8, 1908.)

Zinc Plating.—To plate iron and other metallic surfaces with a coating of zinc C. Bifico recommends an electrolyte made up of 50 to 150 parts of zinc, 2 to 15 iron, 0.5 to 10 aluminium, 0.5 to 10 sodium, 80 to 280 sulphuric acid, 0.5 to 8 acetic acid and 886.5 to 527 water. A soluble zinc anode is used. (905,785, Dec. 1, 1908.)

Discharges Through Gases.

Electrodes for Arc Discharges.—A. G. Davis (General Electric Co.) recommends the use of magnetite (Fe_3O_4) electrodes for arc discharges through gases to produce certain chemical reactions in the gases. The electrodes may be made by pulverizing natural magnetite, mixing with a suitable binder, such as water glass and molding. Electrodes of this kind give a long, brilliant arc; when used for the fixation of atmospheric nitrogen, they are unattacked by the nitric acid and appear to have a catalytic action. (905,666, Dec. 1, 1908.)

Striking Arcs.—When gases are treated by long electric arcs revolving under the influence of a magnetic field (as in the Birkeland-Eyde process) a difficulty is found in striking the arc when the electrodes are far apart. A. J. Peterssen uses an auxiliary arc from another circuit, which may be of low intensity and is moved in the well-known way by electromagnetic means so as to get near the high intensity arc to be struck. The latter is thereby lighted without any necessity of bringing the electrodes near together and without a detrimental effect on the power factor of the circuit. (905,572, Dec. 1, 1908.)

Ozone.—Jan Steynis endeavors to maintain during the ozonizing process the lowest temperature practicable at which temperature the chemical equilibrium gives the largest percentage of ozone. The cooling effect is obtained by means of evaporation of a liquefied gas. The dielectrics between which the silent discharge takes place are flat or tubes and hollow, and of a sinuous tube form, and in the sinuous liquefied gas is allowed to expand so as to produce the cooling effect. Glass plates between the electrodes act as dielectrics. The apparatus is claimed to generate 80 grams of ozone per kilowatt-hour, with a concentration of 3.4 grams of ozone per cubic meter of air treated, and the inventor has been able to pass a current strength of 0.5 ampere with electrodes having 1.4 square meters of surface without undue heating of the apparatus. (906,981 and 906,408, Dec. 8, 1908.)

A recent patent of Dr. Henry Noel Potter (assigned to Cooper Hewitt Electric Co.) refers to "the method of producing and utilizing ozone, which consists in passing an electric current between electrodes inside a container previous to ozonizing radiation, preventing a dissipation of the ozone and transmitting the ozone generated to a selected point." As described in our Vol. V, p. 300, a discharge is produced in a tube of silica (which is pervious to ultraviolet rays) between electrodes of mercury or between an electrode of mercury and one of iron, ozone is produced in large quantities in the air around the silica tube. The latter is enclosed again within another tube of ordinary glass (which is impervious to ultra-violet rays). If air is then passed from one end to the other end through the space between the outer and inner tubes it is ozonized and the ozone is collected. The air is forced to pass between the two tubes in a zig-zag path.

Fixation of Atmospheric Nitrogen.—G. Birkeland, who has done so much in the past to bring this problem to a commercial solution, has recently modified his revolving arc method so as to get a longer arc. The electrodes are placed at a considerable distance from each other. The method is now more similar to that of the Badische Co., while the deviation of the arc by means of a magnetic field is the same as in his former construction. The new furnace is shown in Fig. 1. The furnace B, composed of an iron casing with removable heads and lined on the inside with fireproof material, has a cylindrical shape. The electrodes C project through openings in the heads into the furnace and air is blown into the same through the openings D at one end and the products obtained are taken out through openings E at the other end. The field is created by means of a coil A surrounding the furnace casing, supplied by either direct or alternating current. The arc may be started in any convenient way, for instance, by moving for a moment one electrode near to the other; when again separated the flame will take a form as indicated in the picture and violently rotate within the furnace, thereby also causing the air to rotate, so that a very intimate contact between the air and the flame and a thorough mixing of the products formed with the surplus of air will take place. (906,682, Dec. 15, 1908.)

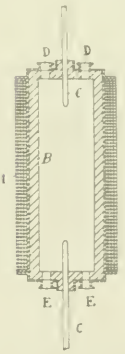


FIG. 1.—FIXATION OF ATMOSPHERIC NITROGEN.

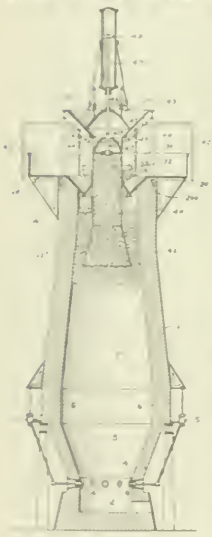
Batteries.

Negative Pole Plate of Lead Cell.—It has been known in the past that the shrinkage of the negative active material and the subsequent loss of capacity can be prevented by adding to the active material certain inert substances, like finely divided carbon, lamp black, china clay, etc. Dr. Edward Sokal has found that the reason why such inactive additions prevent the shrinkage of the negative active material is not a changed behavior of the negative active material, but simply the gassing which must occur there in and around the pores in most particles during the charging operation. That gassing occurs during the charging process is of great importance, because at this time it is most needed, as then the conversion of the spongy lead takes place by reason of the greater concentration of the electrolyte in the pores, and not during the discharge and rest of the battery. Dr. Sokal has now found that lead dust, as a substitute for or combined with finely divided carbon and the other inert materials mentioned above, is very effective. With the addition of lead dust to the negative active material an ordinary grid with pellets completely filling the compartments, and with a separator perforated sheet-rubber or hard

RECENT METALLURGICAL PATENTS.

Iron and Steel.

Modified Blast Furnace Process.—Mr. J. E. Johnson, Jr., [illegible] Va., [illegible] attention to the use of [illegible] (for previous [illegible] see Vol. IV, page 340), endeavors to [illegible] Mr. Gayley. His proposition, made in a [illegible] is a [illegible] more radical and is very inter- [illegible] He [illegible] only the moisture from the air blast, but [illegible] of the nitrogen (which is inert and parasitic in the [illegible] it consumes heat and carries this heat off [illegible] He employs a blast chiefly of oxygen.



BLAST FURNACE.

Mr. Johnson's own method of removing the nitrogen from air is not described, but his would not seem to involve insuperable difficulties. Liquefying of air might be used and the cost would not appear to be prohibitive, in view of the possible gains. The chief gain, pointed out by Mr. Johnson, would be the possibility of doing away with the heating stoves for the blast and with many of the accessories. A further equally radical change proposed is the fusing of the carbon and of the iron ore, not together, but in separate columns. The invention is to oxidize the carbon by the oxygen of the blast to carbon monoxide and to force the carbon monoxide through the iron ore, resulting in the reduction of metallic iron and the formation of carbon dioxide. The latter passes off through the ore column and preheats it, but it does not come again in contact with free carbon, which would result in formation of carbon monoxide. In this way more of the carbon can be oxidized to dioxide than in ordinary blast furnace practice (where only one-[illegible] of the carbon is oxidized to dioxide). A better utilization of the [illegible] value of the coal could thereby be obtained within the [illegible] limit (the same tendency being marked in modern electric furnace designs for iron smelting). The furnace proposed by Mr. Johnson is shown in Fig. 1. The ore is charged from the platform [illegible] into the conical hopper 200, and then into the [illegible] At the center of the hopper 2 is a mantle 40 with holes [illegible] through this mantle the fuel is charged. If the mantle for the fuel and furnace outside of it for the ore were kept full to an approximately constant height, the pressure between the fuel and the ore charged would be determined by the area inside and outside of the mantle at its lower end and the weights of the respective columns of materials above these areas and would be approximately constant, whether [illegible] or [illegible] if provision were made to vary this ratio. The ore being heavier than the fuel, will tend to cut through the [illegible] of the fuel, and the [illegible] of the fuel is, therefore, [illegible] to compensate for this. The purpose of the [illegible] 45 which works with a free fit within the [illegible] of the mantle 45 and presses upon the fuel, [illegible] to be variable faster than the ratio of the [illegible] of the coal fuel charged into the furnace to be consumed. [illegible] a drawing of the method of charging the [illegible] necessary to use coke, but soft coal may be used, and there is no trouble due to the pieces sticking together, since, in this case, it is not desired that the gases should percolate upward through the coal. The fuel column being in the center of the furnace is also out of contact with the walls, and, therefore, any possibility of "hanging" by the adherence of the fuel to the wall is thereby prevented. In view of the radical nature of the changes proposed from ordinary practice—which in principle are sound—it would be very interesting to know what results have been obtained on an experimental scale with this arrangement.

Vanadium Steel.—Dense steel of great strength and high elasticity, without fissures or cracks, for high-speed tools is obtained, according to W. Ruebel, by melting "chemically pure" iron and nickel, or iron and manganese, or iron and tungsten, and chromium, in such proportions as to represent their atomic weights, and then adding not more than 3 per cent of vanadium carbide. Vanadium alone may be added, if the steel contains the corresponding amount of carbon. "The quantity of vanadium in the alloy should not exceed a certain proportion, 0.3 to 3 per cent being the most favorable." . . . "To obtain, for instance, steel of a strength as to bear 150 kg for each square millimeter and of 10 per cent elongation or extension, the necessary quantity of iron is melted with the nickel, mixing them in such manner as to have 0.9 per cent carbon. In melting the percentage is reduced to 0.5, then 1.05 per cent of vanadium is added, either as vanadium or ferrovanadium, and the alloy is allowed to boil for about two hours. The slag formed absorbs part of the vanadium, leaving but about 1 per cent in the alloy." (906,937, Dec. 15, 1908.)

Zinc.

Zinc from Slag.—The amount of iron and zinc, and also of manganese left in slags from copper and lead smelting, is a problem of commercial importance which has attracted the attention of Mr. Anson G. Betts, the distinguished pioneer of electrolytic lead refining. His method of extracting iron and zinc from slag may also be considered as a new process of zinc smelting: generally zinc ores contain other valuable metals, lead and copper, for instance, and frequently these are separated at some cost and with much loss before smelting. Mr. Betts proposes to omit this preliminary separation, to smelt the ore in substantially the usual manner in blast or reverberatory furnaces, and to recover the zinc, iron and manganese from the slag. For this purpose the molten slag poured into a suitable furnace, treated with silicon or a silicide; ferrosilicon containing sufficient iron to materially increase the specific gravity is suitable. The reactions ensuing are, of course, $2\,FeO + Si = 2\,Fe + SiO_2$ and $2\,ZnO + Si = 2\,Zn + SiO_2$. The iron separates at the bottom of the furnace, while the zinc boils off and is condensed. If the slag contains manganese, most of it is found in the iron, if sufficient silicon is used. To recover zinc from zinc ores, the roasted ore may be added to a copper, lead or other smelting furnace, collecting the zinc from the slag; or the zinc ore may be melted with a suitable slag or flux and the zinc removed by silicon, while part or all of the resulting slag or cinder is returned to the process as a flux for more zinc ore. One pound of silicon reduces about four pounds of iron, or four and a half pounds of zinc. The process is applicable to low-grade materials, "and the necessary energy can be supplied by the cheap combustion of fuel up to a certain temperature, and when the efficiency of energy supply by this means becomes low, at, say, the melting point of ordinary slags, a more expensive but more efficient and convenient supply of energy is only then added, in the shape of silicon." The commercial success of the whole process depends, of course, on the price of silicon; this is an electric-furnace product, and, as is well understood, the cost of silicon depends chiefly on the cost of electric power. (905,280, Dec. 1, 1908.) Mr. Betts has also worked out an analogous process for the recovery of manganese from slags. On acount of the complete analogy it needs no further description. (905,281, Dec. 1, 1908.)

Pyrometry of Continuous Furnace Processes.

BY CHAS. E. FOSTER.

By a continuous furnace process is meant one in which the furnace temperature is kept as steady as possible while the pieces of work under treatment are passed into the furnace and out again in a more or less continuous manner. One of the conditions of such a process is that the furnace temperature is considerably higher than the maximum reached by the work. This being so, the final temperature of the material will depend, firstly, upon the temperature maintained in the furnace, and secondly, upon the time during which the material is subjected to that temperature.

This method of furnace operation is applied to many of the most important operations in the metallurgical industries, and, of course, needs special study.

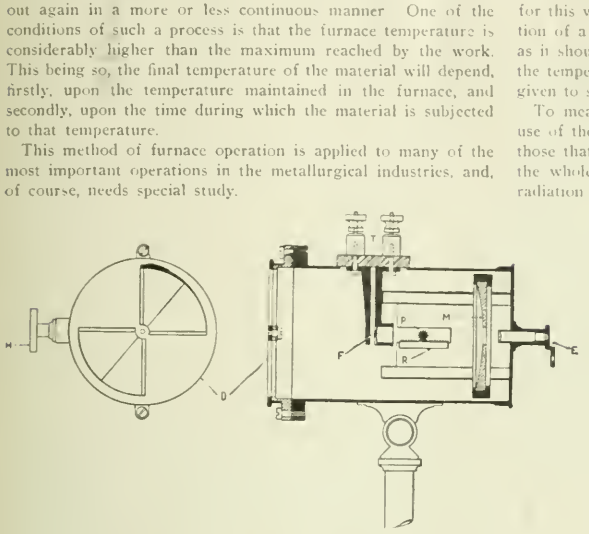


FIG. 1.—FRONT ELEVATION AND SECTION OF FERY PYROMETER.

The highest efficiency will be realized in any case when the furnace temperature is kept continuously up to the safe maximum, while the work is fed through the furnace at the highest speed that secures a sufficient heating to give the desired final temperature. It is in the determination of this safe maximum temperature of the furnace that pyrometry plays such a vital part.

The highest safe temperature will probably be fixed by one of the following considerations:

(a) The maximum capacity of the heating apparatus.

(b) The maximum safe temperature for the furnace lining.

(c) The danger of overheating the outside of the work before the interior gets up to the required finishing heat.

(a) With modern furnaces, oil or gas fired, or worked on a regenerative principle, there should be little difficulty in getting sufficient heating capacity. The amount and distribution of the air supply will be a point requiring careful study.

(b) The highest safe temperature for the fire brick can be ascertained by noting that point of the wall or roof which is hottest and then running up the heat till it is found that the brick begins to flux.

(c) The safe temperature to avoid burning the outside of the work can also be found in a similar way.

Having decided by experiment which of the three conditions gives the lowest limit, then the first of the two main factors is settled. It now remains to determine the highest speed at which the work can be passed through the furnace to come out hot enough for the purpose in view. This is the second and last factor by means of which the highest duty can be got out of a given furnace. There is no need to dwell on the savings in running cost and the increase of output that would result from this method of handling the temperature problem.

In looking at the above outlined series of experiments, it will be seen that they all involve the measuring of temperature. And on closer inspection they all require the measurement of a *surface temperature* and three of them *inside a furnace*. The remaining measurement can be made outside the furnace, but should be on *moving objects* to get the proper working conditions. It is, therefore, evident that the thermocouple of the LeChatelier type cannot be successfully applied. The pyrometer for this work must work quickly and at a distance. The junction of a LeChatelier thermocouple (if it is properly protected as it should be from furnace gases), must be actually raised to the temperature to be measured, and considerable time must be given to secure accurate readings.

To measure high temperatures at a distance we must make use of the radiations given out by the hot body. We may use those that are visible to the eye, as in the optical pyrometer or the whole heat radiation, visible and invisible as in the Fery radiation pyrometer, and the latter is much to be preferred.

The use of an optical pyrometer involves skill on the part of the operator: it depends on the matching of two degrees of brightness, one of them the standard. The standard must be frequently calibrated to insure its constancy and the actual temperature reading is made by reference to a conversion table. Now, all of these considerations render the optical pyrometer a laboratory instrument rather than a works pyrometer.

With the radiation pyrometer invented by Prof. Charles Fery, of Paris, the disadvantages named above are not met. There is no color matching to do and the instrument once pointed is both instantaneous and automatic in its indications of temperature.

In order to show the fitness of the Fery pyrometer for the work in hand a somewhat detailed description of the instrument is given.

In Fig. 1, on the right is shown a longitudinal section of the pyrometer, while on the left is a front elevation.

A certain proportion of the heat radiated by any hot body is caught by the concave mirror *M*, and brought to a focus at *F*. Heat rays can be caught and brought to a focus just as light rays can; in fact, they are broadly the same thing, so that wherever we concentrate light at a focused image, we are also there concentrating heat in just the same way. The "burning glass" forms a heat image of the sun, and the temperature in that heat image is hot enough to scorch a piece of paper.

As the distance is varied between the hot body and the mirror *M*, the size of the focused image varies in the inverse way; for instance if the hot body has a diameter of two inches and the focused image a diameter of one sixteenth of an inch, then, if the mirror be moved to half the distance, the same hot body will give a focused image of one-eighth of an inch. Since the heat received and focused by the mirror *M* varies inversely as the square of the distance, the effect of moving to half the distance is to concentrate four times the energy at the focus. But we saw that the diameter of the focused image was then double its first value, hence its area will be four times and therefore the effect of moving the mirror up to half the original distance is to concentrate four times the heat over four times the area, leaving the intensity just the same. According to these principles the temperature at the focus varies with the temperature of the hot body but is independent of the distance.

FIG. 2. FOCUSING DIAGRAM

Now, in order to get a reading all that is needed is some sensitive means of measuring the temperature at the focus. For the instrument to be sensitive as a whole, this temperature measuring portion of it must be very sensitive. To make the pyrometer quick acting, the heat capacity of the sensitive part must be very small, so that it heats up or cools instantaneously. Lastly, this sensitive device must be sensitive only to the

temperature of the focused image and not to general air temperature.

These conditions are correctly fulfilled by the use of a very small and light thermocouple as the sensitive device. This thermocouple is so arranged that one junction is exposed to the focused radiation, while the second or comparison junction is screened from this focused heat. But both junctions are so close together that changes in air temperature affect them both alike. The e.m.f. developed by the thermocouple will therefore depend only on the focused radiation. In order to make the measurement one of *temperature* and not of *total heat* at the focus, all that is necessary to do is to select a portion only of the focused image and to let that portion be a constant area, no matter what the total size of the focused image

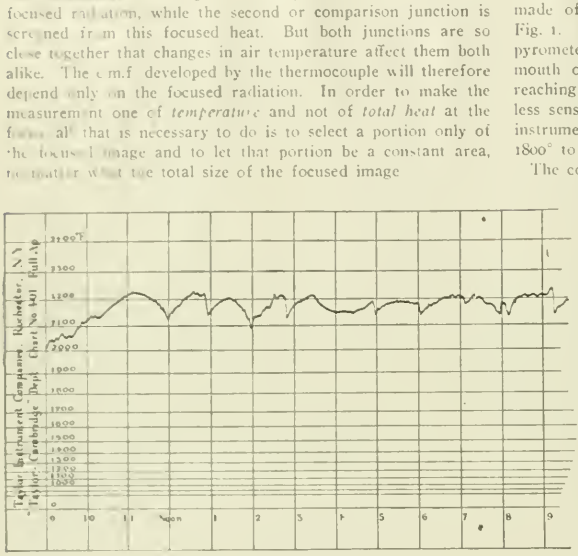


FIG. 3.—RECORD CHART (REDUCED SIZE).

To complete the pyrometer we have now only to provide a means of pointing and focusing and then to use a millivoltmeter to measure the e.m.f. developed by the thermocouple.

The pointing and focusing are done in a very ingenious way. The focused radiant heat reaches the thermocouple junction through a small hole in a diaphragm, and the size of this hole fixes the portion of the focused image that is used to heat the junction. Surrounding the hole, which is at *F*, Fig. 1, are two semi-circular mirrors. These two mirrors are set at a slight angle one to another so that, when the observer looks through the eye-piece *E*, he sees an image that is split into two halves. These two halves do not join up properly and match until the focus is correct. In Fig. 2 are shown two views of what would be seen through the eyepiece, that on the left being out of focus and on the right correctly focused. The focussing is done by the milled head *H*, Fig. 1, which, by means of the rack *K* and pinion *P*, varies the distance between the mirror *M* and the thermocouple at *F*. In order that the measurement may be independent of the size of the focused image, it is necessary that the image shall completely fill the hole in the diaphragm mentioned above. Looking through the eye-piece *E*, Fig. 1, the observer sees the hole as a black spot (see Fig. 2), so that all he has to do is to be sure that the focused image overlaps the black spot all around. Thus, by this simple arrangement the operator is able to determine at once (1) that the pyrometer is correctly pointed (2) that it is near enough to the hot body, and (3) that it is focused. These three things, which are all done in one operation, represent the only optical part of the apparatus, the rest of the action being automatic and continuous.

By means of a flexible cable attached to the binding posts *T*, in a separate millivoltmeter is connected in the thermocouple circuit. By calibration on actual high temperatures against accurate standards, the scale of the millivoltmeter not only reads in millivolts, but also in temperature of the hot body. Thus the user has only to watch a pointer moving over a scale to read directly the temperature of the hot body at which the pyrometer is pointed.

In order to give great sensitiveness at medium temperatures, and at the same time to enable very high temperatures to be measured with the same instrument, a very ingenious use is made of an adjustable diaphragm. This is shown at *D* in Fig. 1. When the pointer reaches the top of the scale with the pyrometer fully open, the diaphragm *D* is swung over the mouth of the pyrometer, thus reducing the amount of heat reaching the mirror *M*. In this way the instrument is rendered less sensitive and a second scale is obtained. In the standard instrument the two scales are from 1000° to 2400° F. and 1800° to 3600° F. respectively.

The complete portable outfit includes a collapsible tripod for holding the pyrometer pointed as desired, and also a carrying case to contain the whole outfit.

It will be evident that with this Fery pyrometer the temperature problems indicated previously can be easily dealt with. The pyrometer can be quickly pointed in any desired direction and the user can identify with certainty the object upon which it is sighted. Thus the temperatures inside the furnace may be rapidly explored and the hottest part quickly found. Then the firing may be studied by leaving the pyrometer sighted on the desired part of the furnace and varying the air and fuel supplies. Lastly, the actual temperatures of the work as it passes through the furnace can be accurately measured.

Where the problem calls for continuous recording of the temperatures, the pyrometer may be set up on a steady support and the place of the indicating millivoltmeter taken by a sensitive, autographic recorder called the Thread Recorder. This instrument produces a continuous record in ink in a very simple and accurate manner while avoiding any errors that would arise from pen friction.

If for any reason it is found inadvisable to have an opening permanently in the side of a furnace, the Fery pyrometer can

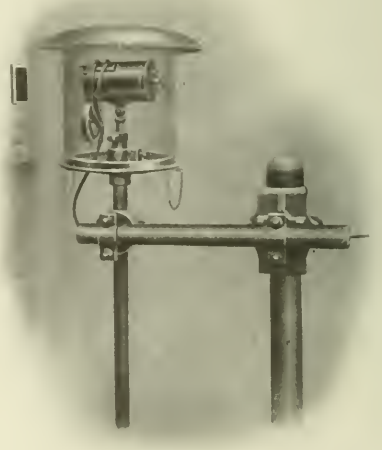


FIG. 4.—FERY PYROMETER WITH BRACKET AND WEATHER-HOOD.

still be satisfactorily used for measuring the temperature of the furnace by the insertion of a tube closed at the inner end through the wall of the furnace. This tube will then take up

the furnace temperature and the Fery pyrometer can be sighted into the closed end. The appearance of the pyrometer under these conditions is protected by a weather-hood. This is shown in Fig. 4.

The cover over the instrument is shown as a ghost, but it is actually of metal and has an aperture in the front to admit the radiant heat, and a slit at the back by means of which the pointing can be verified after the weather-hood is on.

These instruments are now manufactured and sold by the Taylor Instrument Companies, of Rochester, N. Y., as that firm has recently taken over the whole American business of the Cambridge Scientific Instrument Company, of England. The whole pyrometric field as covered by the Cambridge instruments is now included under the distinctive title of "Taylor Cambridge."

A Model Chemical and Metallurgical Laboratory and Testing Plant.

The laboratory and testing plant of Dr. Chas. Theo. Hennig, described in the following article, may be justly called a model plant. They are unique in the scope of the research work which is carried out there, while the equipment has many admirable features. The testing plant is located on East Thirty-fifth Street and the Long Island Railroad, Brooklyn, N. Y.

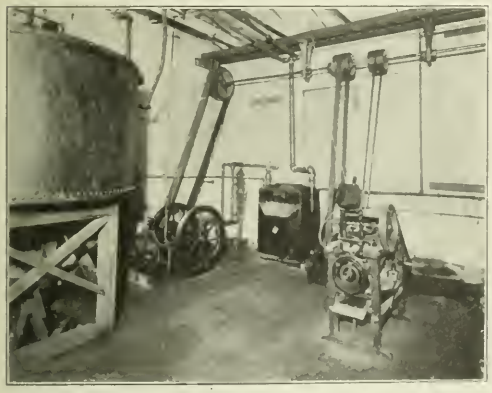


FIG. 1.—MAGNETIC SEPARATOR AND ONE OF THE CYANIDE TANKS.

The research laboratories and the library are located at 1020 New York Avenue, two blocks from the testing plant.

The research laboratory is probably the best equipped of any private laboratory in existence, and contains as complete a set of apparatus as is ever used in metallurgical research. It contains powerful microscopes and some of the most delicate scales in existence, as well as all the apparatus for pyrometry, microscopy, spectroscopy, etc. The library contains over 5000 volumes devoted to metallurgy, chemistry and allied sciences, and has books dating from the seventeenth century to those of the present. (In parenthesis it may be said here that a glance over the illustrations of Agricola's Metallurgy of 1657, which is found in Dr. Hennig's library, brought home to the writer of this note the fact that some mechanical appliances and arrangements, widely used in modern engineering works, are not the result of inventions of the last century, as we sometimes fancy. Some of our forefathers of the seventeenth century were good engineers, too.)

The work carried on by Dr. Hennig and his corps of assistants extends from the isolation of rare minerals to the casting of steel ingots. Dr. Hennig has in his possession 53 elements, most of which have been isolated under his special supervision.

The testing plant is of very wide scope. It is midway between an ordinary laboratory and a large commercial chemical or metallurgical works. It is, in fact, a commercial works on a small scale, so equipped that a whole process may be carried out there, beginning with ore crushing and concentration, fol-

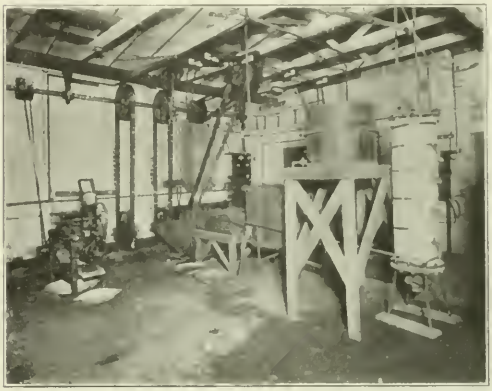


FIG. 2.—LEACHING AND PRECIPITATING PLANT FOR REFRACTORY ORES.

lowed by roasting, smelting, refining, or whatever the metallurgical treatment may be, and ending in a finished product which is submitted to mechanical and chemical tests—all these operations and tests being carried out under one and the same roof.

The equipment of the plant, most of which is interchangeable to allow for the variations in different processes, therefore provides for the following lines: Crushing and sizing (by crushers, stamp mills, rolls, etc.), amalgamation, cyaniding, magnetic separation, roasting, blast-furnace smelting, electric smelting, electrolysis, leaching and chlorination.

It is a pity that on account of the confidential nature of most of the work, we cannot give details of the various researches carried out. But to give an idea of the scope of the work it

may be mentioned that it relates, among others, to such different problems as a new process for working complex lead-zinc ores, a new nickel-silicide process, numerous researches on special steels and ferro-alloys and alloys in general, new arc lamps, metallic-filament lamps and incandescent gas lamps.

The building which contains the testing plant has four departments. In the front room are contained a stamp mill, plants for concentrating, cyaniding and leaching; apparatus for

apparatus for electrolytic work; steam pump, ore feeder, air compressors, etc.

In the mineral room are rolls, sample mills, crushers, screens, a [illegible] furnace (24 in. diameter, 12 ft. deep), and a 1/2-ton power hammer for testing steel bars.

The main room contains several large pieces of machinery, the largest of which is a 75-hp Springfield gas engine. Preparations are being made to install one of 100 hp. Here also are a 60-kw Lundy dynamo and six electric furnaces for the smelting of refractory metals, making carbides and the different alloys of nickel, chromium, molybdenum, tungsten, vanadium, titanium, thorium, etc.

FIG. 4.—ELECTRIC FURNACES AND SWITCHBOARD.

On one side of the building is a room containing a 25-hp White & Littleton gas engine and a dynamo for the small electric furnaces, while on the other side is the chemical laboratory.

The power necessary for the plant as a whole is derived from [illegible] of different makes, ranging from a 3- to a 75-hp unit, having a total of 130 hp.

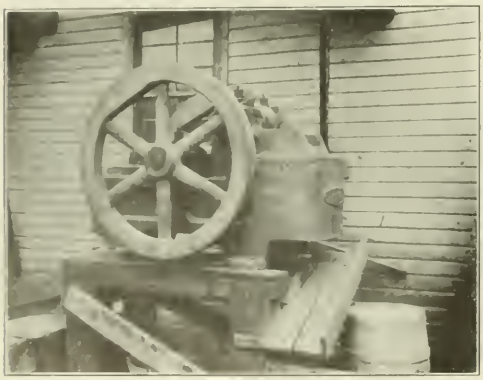


FIG. 5.—CRUSHER.

New Ore Concentrator.

Construction of Concentrating Table.—An interesting recent feature of the testing plant is the Hennig concentrating table, which, as the outcome of considerable experimentation with refractive ores that could not be handled by other tables, it has the following advantages:

The driving gear is in one piece and includes fast and loose pulleys, balance wheel and double eccentric drive. Three-quarter horse-power is required to drive the table. The longitudinal oscillations may be varied from 0 in. to 15/16 in.—the rate of the oscillations ranging from 150 to 180 per minute.

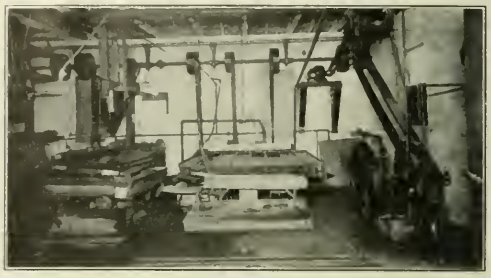


FIG. 6.—CONCENTRATION ROOM.

The riffles are made of semi-circular lead strips—the total length of which is 1256 ft. for each table. Each lead strip is 5/16 in. wide and 3/16 in. high, except when flattened. At the feed end of the table the distance between the riffles is 3 in., while at the discharge end it is only 3/4 in. These figures, of course, vary, the variation depending upon the kind and quality of the ore under treatment.

As before said, the riffles are flattened as the discharge end of the table is approached, and this is accomplished by passing the lead strips through a hand-power rolling machine. The lead strips are shaped in a wooden mold.

A special feature of this machine is the arrangement of the riffles in sinuous curves.

The foundation of the table consists of three 5-ft. cross-pieces made of 8-in. x 8-in. timber, and resting on these cross-pieces are two 9-in. channel bars. The table proper rests upon the two cross-pieces, the four corners of which are fitted with short steel pins that have ball ends. These pins work freely in sockets fitted to the ends of the cross-pieces on the bottom of the table.

FIG. 7.—COMPLETE TABLE.

Fixed rigidly to the channel bars are the cross-pieces, and projections from the cross-pieces work freely between guides attached to the bottom of the table. The guides may be set at any angle with the line of the driving rod, thus giving to the table the required amount of side motion.

In addition to the longitudinal and the side motion, the table is also capable of a rocking motion, which motion is imparted

by the ball-and-socket arrangement. Taking all these movements into consideration, the motion of the table when in operation is very similar to that imparted by the prospector to the ordinary pan.

The feed trough is 15 ft. 7 in. long, 3 in. high, 8 in. wide at the feed end, and 3 in. wide at the discharge end. Gate-like partitions divide the trough into five compartments, the gates consisting of a strip of wood that can be raised or lowered and fixed in any position. The gates are capable of adjustment so as to leave a space anywhere from 1/16 in. to 5 16 in. The pulp is charged onto the table through holes placed 2¼ in.

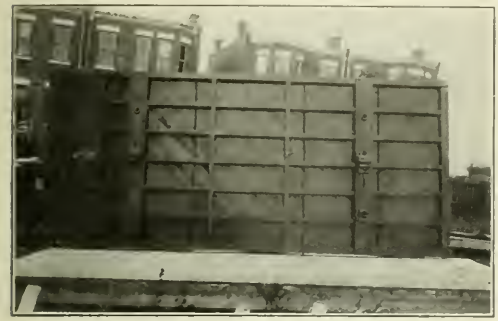


FIG. 8.—BOTTOM OF TABLE.

apart in the outer side of the feed trough. At the feed end of the table these holes are ¾ in. in diameter, while those at the discharge end are only ⅜ in. The feed trough is capable of adjournment to within 0.001 in.

Operation of the Table.—The ore is allowed to pass into the wide end of the trough at the head of the table. The gates being adjusted, a concentrating effect is obtained by the grooves in the bottom of the trough, and the mineral portion of the feed collects in the groove and passes on toward the discharge end

FIG. 9.—HEAD MOTION OF TABLE.

of the table. The overflow from each compartment passes by means of the holes referred to onto the table proper. The quality of the pulp feed through the holes and the fineness of the concentration in the feed trough depends upon the inclination of the trough and the space left under the gates.

By this arrangement about 90 per cent of the concentrates are made in the trough, only the balance of the pulp passing over the table. Through the agency of the curved rod and the gyratory motion of the table the pulp is washed at every curve and within the arc of each curve, thus making the concentrating process continuous over the entire length of every riffle

The average capacity of the table is about 50 tons per 24 hours.

Our thanks are due to Dr. Hennig for the information contained in this article and for many courtesies shown to the writer during a whole afternoon's visit to the laboratory and testing plant.

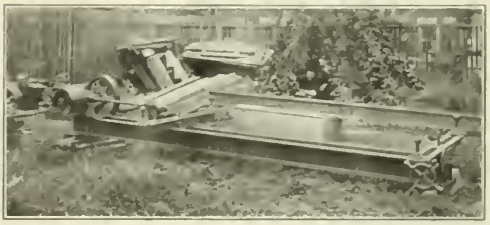


FIG. 10.—SUBSTRUCTURE AND TIPPING ARRANGEMENT.

Ozone for Purification and Regeneration of Air.

The Siemens & Halske Co. of Germany have paid for many years great attention to the production of ozone by the silent electric discharge. The late Werner Siemens was a pioneer in this field as in so many others. It is well known that while the fixation of atmospheric nitrogen (that is, the combination of the nitrogen and oxygen contained in ordinary atmospheric air) essentially requires an arc or spark discharge, the transformation of oxygen into ozone requires the so-called silent

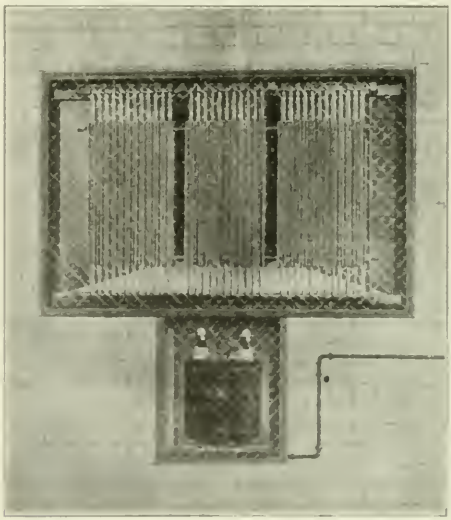


FIG. 1.—OZONE VENTILATOR.

discharge and the formation of an arc would be fatal. While the combination of the nitrogen and oxygen to nitrogen oxide due to the arc is, to a large extent at least, a thermal phenomenon, the formation of ozone, which may be represented by the equation $3O_2 = 2O_3$ (the two atomic oxygen molecules being changed into three-atomic ozone molecules), appears to be a specific electric phenomenon, the exact nature of which is not yet fully understood, although a photo-electric effect due to ultraviolet light seems to be involved.

Whatever the theory, ozone has proven very successful in

practice under the care of the Siemens & Halske Co. It is unnecessary to describe in detail again the old and well-known Siemens ozonizer (see Vol. I, page 179). It is of the well-known construction with glass as dielectric. In the past the Siemens & Halske Co. have pushed the use of their ozonizers especially for two purposes.

One was the treatment of ordinary starch with ozone yielding a product called "ozone starch," which with its properties stands halfway between starch and dextrine. Like true starch ozone starch is insoluble in cold water, but dissolves in hot water without forming a paste like dextrine. For this property ozone starch is used extensively as a binding material for paints and colors and for printing on cloth, linen and all kinds of fabrics.

FIG. 2.—PORTABLE OZONE VENTILATOR.

The second and even more important industrial application has been sterilization of drinking water. Ozone apparatus for this purpose are made for use in houses and hospitals, and have found a ready sale, especially at times of epidemics. That, however, the use of ozone on a large scale for sterilizing the drinking water of a whole town is commercially possible is proven by the city of Paderborn, in Germany, which has been equipped with ozone apparatus for some five or six years. These have been in continuous use and it is a significant fact—not a theory—that the typhoid epidemics which came at regular intervals before, have now absolutely ceased since the introduction of the ozone treatment.

Quite recently, however, the Siemens & Halske Co. are using their ozone apparatus also for the purification and regeneration of the air. The fundamental fact is that the strong oxidizing nature of ozone is able to regenerate foul air even without the supply of fresh air. Of course, ozone may also be used in combination with fresh air supply. The ozone molecules give off their third oxygen atom, which oxidizes the impurities in the air, while the remaining bi-atomic oxygen molecules bring up again the air to the desired concentration of oxygen.

For this purpose it is not necessary to use a high ozone concentration. Practice has shown that with 0.05 to 0.5 gram of ozone per cubic meter the desired deodorizing and purifying effect is obtained.

If the building (or mine, etc.) is equipped with a ventilating system, the ozonizers are simply inserted in the air-ventilating shafts. Fig. 1 shows the arrangement of the ozonizer of the Siemens & Halske Co. for this purpose. It consists of alternating metallic rods and plates, forming the two opposite poles connected to the high tension side of the auxiliary transformer, which is part of the ozonizer and one pole of which is earthed for the sake of safety.

The metallic rods are enclosed in glass tubes forming the dielectrics which cause the silent discharge and prevents the arc formation. The air passing through the ozonizer is ozonized and is then supplied through the ventilating system to the different rooms of the building. The consumption of energy is relatively low. Apparatus for ozonizing 1000 to 5000 cubic meters of air per hour require about 30 to 150 watts.

If the building is not equipped with a ventilating system, different methods are possible. Fig. 2 shows a portable ozone-ventilator which may be placed in any room. In this case, of course, there is not simply a supply of fresh air, but only regeneration of the old foul air as explained above. The apparatus is connected to the electric wiring system, just like a lamp or a motor. Of course, this presupposes that the supply system is alternating current; otherwise a small converter or motor-generator is necessary.

Fig. 3 shows an ozone ventilator which is inserted within a hole in the wall, the fan driving fresh air from the outside into the room. The largest part, however, of the air is pressed through the ozonizer and thereby ozonized. When ozonizing 10 to 60 cubic meters of air per minute these ozone ventilators consume about 175 to 900 watts, including the power necessary for driving the fan.

These ozone apparatus have proved useful for ventilating factories, workshops, storerooms, meat packing houses, theaters and meeting halls. Particularly useful they have also proven in the case of a tunnel railroad and on board ship, and there is no doubt that they could also be advantageously employed for ventilating mines, although, of course, in the case of coal mines the danger of explosions would be prohibitive.

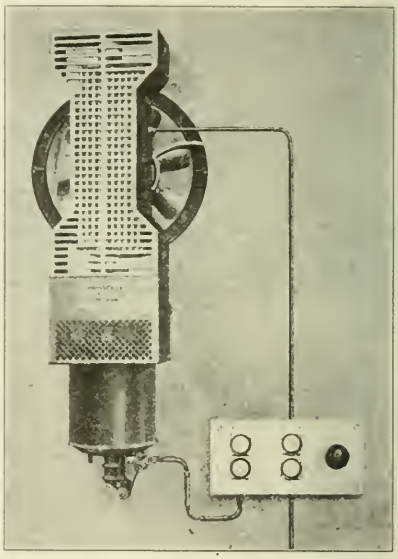


FIG. 3.—OZONE VENTILATOR IN WALL.

These apparatus are now being introduced in this country by the American branch office of the Siemens & Halske Co. and the Siemens-Schuckert Co., in charge of Dr. K. G. Frank, Room 1559, Hudson Terminal Building, New York City.

A New Departure in Pyrometer Design.

An interesting, self-checking pyrometer, radically different from previous types, has recently been developed and placed on the market by the Leeds & Northrup Co., of Philadelphia.

It is especially intended for use where it is desired to hold the temperature of an oven, vat, etc., at a given value, and for this class of work, combines the accuracy and constancy of a Wheatstone bridge measurement with the ease and convenience of a deflection measurement.

The pyrometer consists of two parts: the bulb or fire-end, and the indicator. The bulb is a coil of platinum wire, enclosed in suitable porcelain or quartz tube, protected by seamless nickel tube. The indicator consists of a Wheatstone bridge, mounted on the base of a regular switchboard-type ammeter. It operates on any direct-current system, and is practically independent

of voltage fluctuations in the supply. Any number of bulbs located at any distance may be read on one indicator through a suitable switchboard.

Owing to the fact that the energy used in the electrical system is supplied from an outside source, the amount may be made as large as is used by a regular switchboard ammeter. A regular stock ammeter, without shunt, is used, and hence this instrument is as heavily constructed, as robust, as reliable and as constant as a switchboard ammeter.

The constancy of the platinum resistance bulbs is shown by tests made by the National Bureau of Standards. Resistance bulbs in practically constant use for over two years at 1800° Fahr. show a change of less than 6° Fahr.

The regular indicator is supplied with a 5-in. 220° Fahr. scale, and has extension plugs to extend the range to 1000°, thereby giving the instrument the equivalent of a scale 25 in. long. It is available for any range below 1800° Fahr.

Due to an overlapping scale, this instrument may be checked up at four points throughout its range without disturbing any part of the apparatus.

PYROMETER.

As is above stated, the instrument employs the Wheatstone-bridge method. At one point for every 200° of its range, the Wheatstone bridge is balanced and the readings of the instrument are independent of calibration of the ammeter.

This balance point is placed in the center of the scale. If the ammeter, due to any cause, is 3 per cent off calibration, the error in the temperature is 3 per cent of 100°, or 3°. If the temperature, being measured, is 1800°, the error due to the reading instrument would be 3°. All the conventional types of electrical deflection pyrometers have the galvanometer scale cut to cover the entire range. If such an instrument had its galvanometer off calibration by 3 per cent, its error at 1800° would be 54°.

To look at the principle of the instrument somewhat differently, the great bulk of the measurement is made on the Wheatstone bridge, the ammeter taking the residual, consequently, an error in the ammeter only affects the measurement of the residual, which equals only 100°. Constructed as it is of non-movable, perfectly protected standard resistance coils, nothing short of absolute and wilful abuse can injure the Wheatstone bridge. From the fundamental principle of the bridge, it is independent of the voltage of the circuit which supplies the energy.

This balance point may be placed at such values as will best adapt the instrument to the needs of the user, and will then indicate departures from this temperature so clearly that a workman can stand at a considerable distance from the indicator and clearly note if the temperature is too cold or too hot.

The portable type of indicators made by this company are entirely independent of the calibration of a galvanometer. The measurement is made on a scale 16 in. to 25 in. long, located on a circle 6 in. to 8 in. in diameter, the galvanometer merely indicating when the operator has turned the index to the proper position on the scale. With this type of instrument, which has been, for some years past, used in many industrial establishments, in the hands of men unable to read English, the Leeds & Northrup Co. are prepared to guarantee an accuracy of 5° at 1700° Fahr.

Transport of a Tube Mill.

The installation of mining and metallurgical machinery in out-of-the-way places often involves considerable difficulties. In many cases these can only be overcome by special construction

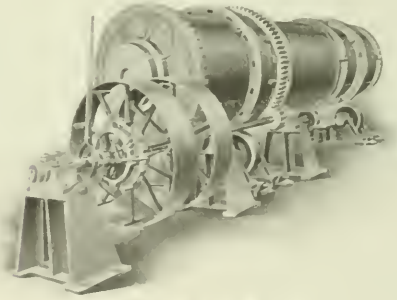


FIG. 1.—THREE-STAGE TUBE MILL.

of the machinery in sections which permit easy transportation.

An interesting instance of this kind is the construction of four large tube mills, built by the Abbé Engineering Co., 220 Broadway, New York City, for the Ventanas Mining & Exploration Co., of Mexico. These tube mills are 4 ft. 6 in. in

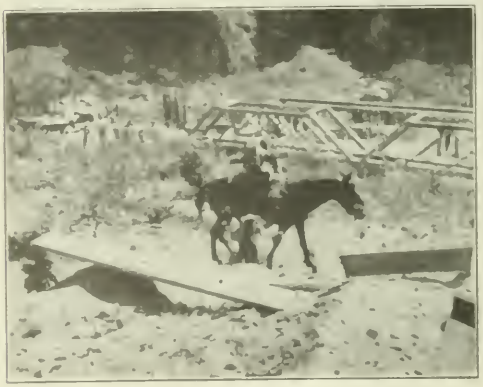


FIG. 2.—MILL WITH SECTIONAL HOUSING.

diameter and 18 ft. 5 in. long, and each weighs complete 51,000 lb. This weight is made up of 26,000 lb. of metal work, 16,000 lb. of selected flint pebbles, and 8,000 lb. of silex lining.

[illegible] had to be transported to the mine on [illegible] they had to be sectionalized. Fig. 1 shows one of [illegible] tube mills, tire style (patented), as set up [illegible] the erecting shop of the Abbé Engineering Co. before being knocked down and shipped. Since the construction of [illegible] mill of this company, with its characteristic feature of spiral [illegible] and discharge, has been described and illustrated repeatedly in this journal (see, for instance, our Vol. III, page 411), there is no necessity to describe it again in detail.

The heaviest pieces of this sectionalized machine are part of the "Ideal" spiral feed weighing 400 lb.; 12 pieces of shell weighing 340 lb. each; the four chrome-steel rollers, weighing

FIG. 3.—MULE CARRYING ONE HALF OF A LOCOMOTIVE STEEL TIRE.

375 lb. each. Several other pieces weigh 350 lb. each, while the balance of the pieces weigh less than 300 lb. each.

Fig. 1 shows a mule carrying one of the four chrome-steel supporting rollers, on which the mills revolve.

Fig. 3 shows a mule carrying one-half of one of the two locomotive steel tires (four pieces), which surround the mill and which turn on the four rollers above mentioned.

[illegible] 4.—MULE WITH PIECE OF SPIRAL FEED.

Fig. 4 [illegible] the largest piece of the spiral feed on the first [illegible] the second mule.

Fig. 5 [illegible] carrying the different pieces of one of the [illegible] on their backs.

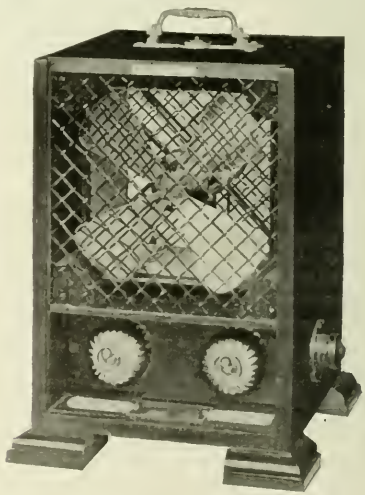
These Abbé tube mills are the largest that have ever been sectionalized in such small pieces, this being practical only with a tire-style machine. These mills at the Ventanas plant have

FIG. 5.—TWENTY MULES CARRYING ONE TUBE MILL.

now been in operation for some months and are giving entire satisfaction.

New Commercial Ozonizer.

Ozonair Co., Ltd., of London, have placed on the market a new apparatus for the commercial production of ozone by the silent electric discharge. The discharge takes place between two surfaces of metallic wire gauze, oppositely changed from a high-tension alternating-current transformer, while a plate of mica or micanite acts as dielectors. The chief feature claimed for



OZONIZER FAN.

the apparatus is complete freedom of the ozone from any nitrogen oxides (which would be formed immediately if there was any spark or arc discharge).

The principle of the construction is that each corner of mesh of the metallic-wire gauze represents a point from which a silent discharge starts. As there are an immense number of such points on the surface, the silent discharge is distributed over the whole electrode surface, being very finely subdivided. The air is forced to pass over the whole surface and the oxygen is thereby changed to ozone, the plate acting at the same

time like a baffle plate, forcing the air into the desired path.

Ozonizers are built by the Ozonair Co for purifying air in houses, hotels and hospitals; for sterilization of water and for all other purposes for which ozone, on account of its strong oxidizing and bleaching effect is suitable (bleaching fabrics bleaching flour, sterilization in laundries, food preservation, maturing of wines and spirits, etc.).

The company pays special attention to the applications of ozone in breweries. One application is to avoid the liability of the yeast to become "weak" or to be affected by atmospheric influences during the fermenting process, and also in the subsequent yeast storage, thus giving a uniform article all through the year. In addition to sterilizing the air and ridding it of all harmful micro-organisms, the purified air is passed on to the wort enriched by the addition of free ozone, which has the effect of invigorating the fermentative action and of strengthening and improving the yeast. For cooling and refrigerating, the objects are somewhat similar, viz, to rid the air of all the solid impurities, and afterward to sterilize it. This is an important feature, as during these processes of cooling or refrigerating, the wort is exposed to the air in very thin layers, and it is thus much more susceptible to the action of the harmful micro-organisms and germs than in any other of the processes of brewing. In bottling with the aid of compressed air it is also necessary to use pure air, and in addition, if the top layer which is left in the bottle be strongly ozonized, there will be no liability of the beer to go bad. The company have installed an apparatus for the above purpose in a large London brewery; it has now been working for considerable time with complete success.

The ozonair apparatus are now being introduced in this country by Mr. A. W. Benttell, 133 Fifth Avenue, New York City. The adjoining illustration shows an ozonizer apparatus for purification of air in houses or hospitals; the air is ozonized by the silent discharge taking place in the apparatus when connected to an alternating-current supply and the ozonized air is blown into the room by means of a small fan.

Duty on Ferro-Alloys.

The old controversy concerning the duty on ferroalloys has come up again at the recent tariff hearings before the Ways and Means Committee in Washington.

In the past ferrosilicon and ferromanganese has been taxed at $4 per ton, according to paragraph 122 ("iron in pigs, iron kentledge, spiegeleisen, ferromanganese, ferrosilicon, wrought and cast scrap iron, and scrap steel, $4 per ton").

Other ferroalloys, especially ferrotungsten, ferromolybdenum, ferrochromium, and ferrovanadium, were not specifically mentioned in the tariff. Hence the controversy between Government and American manufacturers on one side and importers on the other side. This has now lasted several years.

Mr. Evart Brown, representing the Electro Metallurgical Company at the hearing, summed up the controversy as follows: It was claimed, on behalf of the Government and the Treasury Department, that the logical place for ferrotungsten, etc., was in paragraph 183, which provided for "metals unwrought", and it seemed to the Government that that clearly covered them, and that a duty of 20 per cent ad valorem should be put upon them accordingly. The importers, however, claimed that that expression, "metals unwrought," did not cover these articles, that, therefore, there was no niche for them in the tariff act, and that consequently they became non enumerated articles, and in so becoming non-enumerated articles, they became subject to what is called the "similitude clause", that is section 7 of the present tariff act, which provides that when an article is not enumerated in the tariff act it shall be classified and take duty according to the article which it most resembles in material, quality, texture and use.

They claimed that while these articles were not enumerated they were similar to ferrosilicon and ferromanganese, enumerated in paragraph 122, and that, therefore, they took a duty of $4 per ton.

The case went into court in New York, and it was there held by the Circuit Court of Appeals for the Second Circuit that the expression, "metals unwrought," covered only metals capable of being wrought and that it must be such a metal as could be made in and by itself into utensils or definite, particular objects; and that the use of a metal to melt up with other things to make a compound to perfect the compound or for some similar purpose was not such a purpose as could enable an article to be called a "metal unwrought."

That distinction was temporarily accepted by the Treasury Department, and all these ferroalloys came in at a rate of duty of $4 a ton. But consequently the Circuit Court of Appeals in Philadelphia (in the Third Circuit, in another class of goods somewhat similar, to wit, tungsten metal (not ferro-tungsten, but tungsten alloyed with iron), held differently on the proposition of what the term "metals unwrought" meant and the Treasury Department determined to try a new case on the subject to secure what it thought was a reasonable rate of duty.

Mr Brown emphasized that in 1897, when the tariff act was passed, almost all the ferrosilicon was low-grade ferrosilicon made in the blast furnace. This is, of course, much cheaper than high-percentage ferrosilicon made in the electric furnace. Further, ferrotungsten and ferrovanadium are very much higher in price. The Electro Metallurgical Company asked that a duty of 20 or 30 per cent ad valorem should be placed on all ferro-alloys.

The Primos Chemical Company asked that on ferrotungsten, ferromolybdenum, ferrovanadium, tungsten metal, molybdenum metal and their salts, a duty should be placed not less than 25 per cent ad valorem; further, on tungsten ore, which is now on the free list, a duty of 20 per cent ad valorem. Molybdenum and vanadium ores could also be produced in large quantities in the United States if they were protected by a duty of 10 to 20 per cent to induce their production in the United States. As the manufacturer of high-grade steels is so closely dependent upon the alloys and metals in question they should also be considered, and either an ad valorem duty provided for steel valued at above 16 cents per pound or such other provision as would protect this new industry.

On the other hand, Mr. John L. Cox, representing the Midvale Steel Company (as a very large consumer of ferroalloys in the production of special steels), asked to have the tariff on ferrotungsten removed.

Conical Pebble Mill.

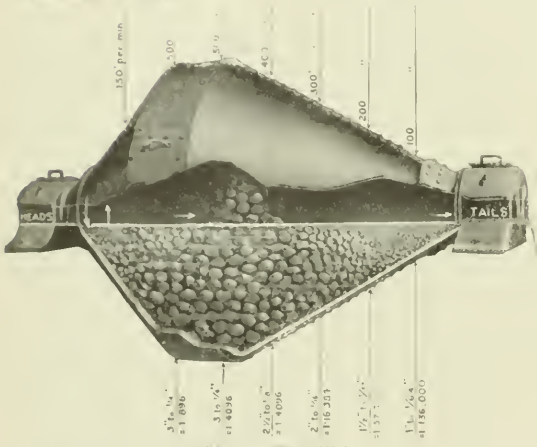
A novel and very curious departure in the design of pebble mills is due to Mr. H. W. Hardinge who described it in a paper presented at the Birmingham meeting, October, 1908, before the American Institute of Mining Engineers. The Hardinge conical mill, which has already proven successful in practical operation, is being placed on the market by the Hardinge Conical Mill Co., 43 Exchange Place, New York City.

As the name says and the adjoining illustration shows the prominent feature of the design is that it is of conical and not of cylindrical shape. The result of this design is a spring action, whereby the pebbles and the particles of material to be crushed arrange themselves according to their size at different sections of the conical mill. The illustration shows the comparative peripheral speed per minute at different sections of the mill, and a diagrammatic comparison of the size and weight of the crushing pebbles and the particles to be crushed. The same increase in the difference as the sizes decrease is comparatively unaltered by the diminished but yet reduced peripheral speed.

Or, in other words, the principles involved of gradual reduction in the cone apparatus through the application of a con-

[illegible] the law of gravity and centrifugal force, result in [illegible] crushing pebbles and particles to be crushed. A circular motion is produced which, while revolving with the same speed in revolutions per minute, contains a multiplicity of [illegible] with constantly changing peripheral speeds.

The [illegible] of the action raises the question as to the main cause of the crushing. But whatever the ultimate cause may be, the result of this crushing effect is that large pebbles pound on large particles of the material to be crushed with a high momentum, and smaller pebbles on smaller particles with a less momentum. Mr. Hardinge says the principle of crushing in his mill is to use a nail hammer upon a nail and a tack-hammer upon a tack, i. e., to adjust the power and mechanism to the work required. This results not only in great uniformity of the finished product, but in a great reduction of the power required for crushing.



NO. A HARDINGE MILL.

The following results were obtained by the Cobalt Central Mines Co., at Cobalt, Ont., in a series of screen tests on the same ore (diabase gangue) extending over a period of several days. They show the adaptability of the Hardinge mill to fine and coarse grinding for cyaniding or concentration.

	Per cent on	Per cent on	Per cent on	Per cent on	Per cent on	Per cent on	Per cent on	Per cent through	
Mesh	8	14	20.	40.	60.	80.	100.	100.	
Heads	16.7	45.1	6	13.9	6.8	4.4	.3	7	
Tails	..	.	4.8	9.8	22.8	22.3	.9	39	First adjustment.
Tails	.	..	.	1.3	8	27.5	2.5	60	Second adjustment.
Tails	.	.	.	..	1.4	10	2	87	Third adjustment.

The average capacity was above 2 tons per hour; the power required, 12 hp to 15 hp., charge of pebbles, 2000 lb.; consumption of pebbles, 1.3 lb (1¼ cts per ton of ore.

The total weight of a conical mill (except the lining), having a capacity of from 2 to 4 tons of material per hour, is 8200 lb. and the floor space occupied is 7 ft. x 10 ft. The charge of pebbles is about 2000 lb., and the power required for operation is from 12 hp to 15 hp. These mills can be arranged readily in series or in tandem, and the large amount of aeration which takes place during the crushing suggests promising results in cyaniding ores during crushing, which, if attained, will greatly simplify present milling practice.

Electric Annealing and Tempering Furnaces.

The [illegible] annealing and tempering furnace, using an electric [illegible] (which has been described in detail in our Vol. IV, p. 502, Vol. V, p. 428, and Vol. VI, p. 410), has such [illegible] that though only a comparatively small [illegible] the field of electrometallurgy of steel, it will undoubtedly find a very large field of usefulness. It has already proven successful and reliable in many installations abroad; its chief advantages are the possibility of adjusting the temperature exactly and easily, the fact that the temperature throughout the whole furnace is almost absolutely uniform, and the simplicity of construction and operation.

This furnace has now been placed on the market in this country by the General Electric Company. We reserve a detailed description of the furnace for our next issue.

Notes.

Electrochemistry at the International Congress of Applied Chemistry.—A note on the organization of the Seventh International Congress of Applied Chemistry, to be held in London from May 27 to June 2, will be found on page 7 of this issue. On going to press, we are informed that papers for section 10 (electrochemistry and physical chemistry) should be sent before March 15 to some member of the American Committee of this section: W. D. Bancroft, C. A. Doremus, F. A. J. FitzGerald, L. Kahlenberg, E. R. Taylor, W. R. Whitney. The membership fee of $5 to the Congress is exceedingly small, in view of what subscribers are to receive—the full Transactions of the Congress, consisting of four to seven volumes. It is important that American electrochemists be well represented in the Congress.

The **Westinghouse** Diary for 1909, just issued by the Westinghouse Electric & Mfg. Co., contains again some new and interesting reading matter on engineering novelties, especially on high pressure and low-pressure steam turbines, the new Leblanc condenser, mechanical stokers, turbo pumps and blowers, tungsten lamps, etc. It is well edited and, in spite of its small size, it gives much useful information on general subjects, including maps, postal regulations, census figures and a list of good hotels in leading cities.

Ozone for a City Water Works.—The City of Taderborn, in Germany, which has had for the past seven years a Siemens ozone plant in continuous operation in connection with the municipal water works, have placed an order with the Siemens & Halske Co. to enlarge the plant so as to double the capacity. One million gallons of water will be purified per day by ozone. This city formerly suffered from periodic typhoid epidemics, which have now completely disappeared.

Duty on Aluminium.—At the recent hearing of the Ways and Means Committee in Washington, Mr. Arthur B. Davis, general manager of the Aluminum Company of America, appeared to urge the retention of the present duty on aluminium, chiefly for the following reasons: During the last four or five years the producing capacity of aluminium abroad was confined to five companies, and these companies were hardly able to supply the demand outside of the United States; but in the fall of 1907 and in the spring of the year 1908, seven more companies started almost simultaneously, and at the same time the five old companies finished large additions to their plants. "The manufacturing capacity by means of these additions and these new plants is about six times the normal consumption of the Continent, and these foreign manufacturing companies are looking to the American market in order to get rid of their surplus product, and so far as we can see there will be no let up to their invasion on this market, and every sale that we make, every quotation that we make, is now made in direct competition with the foreign producers."

Welding of Aluminium.—A few years ago we noticed Mr. W. U. Schoop's new process for welding aluminium, of which he gave a demonstration at a meeting of the New York section of the American Electrochemical Society. The flux used by him for producing an autogenous welding was kept a secret at the time, but has become known through his British patent 24283 of Nov. 26, 1908. According to this patent, the flux is made by adding fluorides of calcium, potassium or boron to a mixture of chlorides of alkali metals.

Aluminium Solder.—Two new solders have recently been patented. H. B. Lambert uses a solder in bar form which is said to be comparatively inexpensive. It consists of 68 per cent by weight of tin, 29 per cent of zinc, 2 per cent of antimony and 1 per cent of phosphorous. (906,637, Dec. 15, 1908.) Another solder is patented by C. G. Carroll and W. H. Adams. It is an alloy of 5 per cent calcium, 47½ per cent tin and 47½ per cent lead. "The combination of the calcium with the other metals produces an alloy whose oxide is formed with a greater evolution of heat per chemically equivalent quantities than are the oxides of aluminium or other metals to be soldered and hence is capable of reducing the oxides of the metals to be soldered through an application of heat while the filling material is capable of attaching itself securely to the surfaces to be joined." (906,383, Dec. 8, 1908.)

Personal.

Dr. **Axel Appelberg**, of the General Electric Co., after a trip through the West, has sailed for Sweden.

Dr. **Eugene Haanel**, accompanied by his son, Mr. B. F. Haanel, has sailed for Sweden to examine a new electric furnace for the smelting of iron ore. This furnace is the outcome of the researches of three Swedish electrometallurgical engineers who have studied this problem for the last three years for a Swedish syndicate interested in iron ore deposits. Dr. Haanel's report to the Canadian government on the results obtainable with this new furnace will be the third of his reports on electric iron and steel processes, his former two reports having marked a new epoch in the electrometallurgy of iron and steel.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Electric Furnaces.

(*Continued from Vol. VI, page 523.*)

577,493, Feb. 23, 1897, Francis Jarvis Patten, of New York, N. Y.

Resistance type. The furnace is a circular vertical shaft, having a carbon lining resting on a metal ring which is connected to one terminal of the dynamo. A vertical carbon pencil is supported centrally within the furnace chamber, resting on a porcelain plate. Horizontal carbon-pencil resistors extend radially between the central carbon rod and the carbon lining, being preferably arranged spirally from top to bottom of the furnace. The charge mixture, e. g., lime and coke, is filled into the chamber and around the resistors. The electric current should be in sufficient quantity to melt the resistors, or at least bring them to incandescence, and is passed either successively or simultaneously through the several resistors, around each of which a nugget of carbide is formed.

579,324, William S. Hadaway, Jr., of New York, N. Y.

Resistance type. Muffle furnace especially for firing porcelain. Above the arched top of the muffle is a concentric perforated fire-clay shell. The muffle and shell are enclosed in a rectangular fire-clay box *F*. The space in the box over the top of the shell is filled with a broken carbon resistor, having carbon block connections at its ends. In use, marsh gas is blown through a pipe into the carbon resistor and air is simultaneously introduced through the space between the muffle and shell and through the perforations in the shell, while electric current is passed through the resistor. The marsh gas is partially decomposed depositing carbon in the resistor and lowering and equalizing its resistance. The gas is also burned by the air, so that the muffle is heated both electrically and by combustion.

579,597, March 30, 1897, Arthur J. Moxham, Johnstown, Pa.

Resistance type. Furnace for heating blooms. The furnace comprises a vertical casing of fire-brick having a hinged cover—an arch of fire-brick held in metal. The casing and cover are lined with a thick layer of asbestos or magnesite. A wire coil resistor is partially imbedded in the inner surface of the asbestos linings. A pipe for supplying a reducing gas leads into the bottom of the chamber, and a pipe opening to a safety valve leads from its side.

582,721, May 18, 1897, James V. Duther, Boston, Mass.

Electrode for arc type furnace. The electrode consists of three superposed cylindrical sections, the upper of magnesia and the two lower of carbon or a mixture of carbon and an alkaline earth. The lower sections are electrically connected by imbedded metal pins and conductive cement. The upper section is centrally perforated and receives a metal rod, the lower end of which is imbedded in the intermediate carbon section. The magnesia sheath section protects the terminal rod from the heat. The lowermost carbon section may be renewed as required.

NEW BOOKS.

THE WORLD'S GOLD: ITS GEOLOGY, EXTRACTION AND POLITICAL ECONOMY. By L. de Launay. 274 pages. Bound in cloth. Price, $1.75 net. New York: Putnam.

A MANUAL OF PRACTICAL ASSAYING. By H. Van F. Furman (revised by W. D. Pardoe). 508 pages. 8°. Bound in cloth. Price, $3. New York: John Wiley & Sons. 1908.

THE ELEMENTS OF PHYSICAL CHEMISTRY. By J. Livingston Rutgers Morgan. 548 pages; figures. 12°. Bound in cloth. Price, $3. New York: John Wiley & Sons.

QUANTITATIVE EXPERIMENTS IN GENERAL CHEMISTRY. By J. Tappan Stoddard. 221 pages. Bound in cloth. Price, $1. New York: Longmans, Green & Co.

MINERALOGY SIMPLIFIED: EASY METHODS OF IDENTIFYING MINERALS, INCLUDING ORES, BY MEANS OF THE BLOW-PIPE, BY FLAME REACTIONS, BY HUMID CHEMICAL ANALYSIS AND BY PHYSICAL TESTS. By H. Erni. 444 pages. Leather binding. Price, $2.50 net. Philadelphia: Henry Carey Baird & Co.

FOUNDRY WORK: A PRACTICAL GUIDE TO MODERN METHODS OF MOLDING AND CASTING IN IRON, BRONZE AND OTHER METALS, INCLUDING MANY VALUABLE HINTS ON SHOP EQUIPMENT AND MANAGEMENT, USEFUL TABLES, ETC. By W. C. Stimpson. 150 pages. Bound in cloth. Price, $1. Chicago: American School of Correspondence.

ELEMENTARY FORGE PRACTICE. By Lord J. Bakon. 289 pages. Bound in cloth. Price, $1.50. New York: John Wiley & Sons.

MACHINERY FOR REFRIGERATION; BEING SUNDRY OBSERVATIONS WITH REGARD TO THE PRINCIPAL APPLIANCES EMPLOYED IN ICE MAKING AND REFRIGERATION, AND UPON THE LAWS RELATING TO THE EXPANSION AND COMPRESSION OF GASES; WITH DESCRIPTIONS AND ILLUSTRATIONS OF THE LATEST MAKES OF ICE-MAKING AND REFRIGERATING MACHINES. By Norman Selfe. Cloth, $3.50; morr., $4.50. Chicago: Nickerson & Collins Co.

THE METHODS OF TEXTILE CHEMISTRY; BEING THE SYLLABUS OF A LECTURE COURSE ADAPTED FOR USE IN TEXTILE LABORATORIES. By F. Dannerth. 172 pages. 12°. Bound in cloth, $2. New York: John Wiley & Sons.

THE STRUCTURE OF THE WOOL FIBER, AND ITS RELATION TO THE USE OF WOOL FOR TECHNICAL PURPOSES: WITH NUMEROUS COLORED AND OTHER ILLUSTRATIONS. By F. H. Bowman. 495 pages. Bound in cloth. Price, $2.60 net. New York: Macmillan.

DYEING AND CLEANING: A PRACTICAL HANDBOOK. By Frank J. Farrell. 240 pages. 78 illustrations. Bound in cloth. Philadelphia: Lippincott.

HARPER'S HOW TO UNDERSTAND ELECTRICAL WORK; A SIMPLE EXPLANATION OF ELECTRIC LIGHT, HEAT, POWER AND TRACTION IN DAILY LIFE, WITH A DICTIONARY OF ELECTRICAL TERMS. Prepared by Jos. H. Adams and Many Illustrations. By W. H. Onken, Jr., and J. B. Baker. 376 pages. Bound in cloth. Price, $1.75.

WATER-POWER ENGINEERING, THE THEORY, INVESTIGATION AND DEVELOPMENT OF WATER POWERS. By Daniel Webster

[illegible] Price, $6 net. New York:

[illegible] Manual of Radiotelegraphy and Radiotelephony for Students and Operators. By Ambrose J. [illegible] Price, $2 net. New York: [illegible] & Co.

[illegible] Crystallography Deciphered. Second revised and [illegible] W. Wells. 317 pages, figures, 12°. Bound [illegible] $2. New York: John Wiley & Sons.

A Dictionary of Engraving, Particularly of the Modern Commercial Processes, Together with Terms Used in Related Industries as Electrotyping, Lithography, Advertising, Printing, Art, Photography, Etc., Idiomatic and Technical. By W. H. Baker. Price, 75 cents. Cleveland, Ohio: William H. Baker.

[illegible] Engines. By Cecil Hobart Peabody and F. Furber Miller. [illegible] pages. Bound in cloth. Price, $4. New York: John Wiley & Sons.

A Text-book of Mechanical Drawing and Elementary Machine Design. By J. Reid and D. Simpson. 451 pages. [illegible] Price, $3. New York: John Wiley & Sons.

[illegible] Pittsburgh. By Harden S. Church. [illegible] Bound in cloth. Price, $1.25 net. New York: De Vinne Press.

BOOK REVIEWS.

Electric Furnaces. The Production of Heat from Electrical Energy and the Construction of Electric Furnaces. By Wilhelm Borchers, Ph.D., professor at the Institute of Technology at Aachen. Translated by Henry G. Solomon. 224 pages, 282 illustrations. Price, $2.50. New York: Longmans, Green & Co.

This is an English version of Dr. Borchers' German book on electric furnaces and comprises over 200 pages devoted to a general illustrated treatment of many of the electric furnaces which have been described previously in print.

Furnaces are classified in accordance with methods of heat application, comprising "direct resistance heating" (in which the charge is itself the resistor), "indirect resistance heating" (in which the charge is in contact with a special resistor), "separate heating," "combined resistance and direct arc heating," "indirect arc heating," to each division of which a chapter is devoted. Other chapters deal with "furnaces arranged for different modes of heating," being chiefly a description of the Borchers experimental furnaces; "the construction of electric furnaces" giving especially details on electrode construction and connections, and "furnace outputs."

The book is well illustrated, there being an average of over two figures per page, and it is pleasing to note many departures from the familiar time-worn cuts which have previously been employed in electric-furnace literature.

The greater portion of the book deals with the historical development of electric furnaces rather than with the features of the typical electric furnace of to-day, and the author's obvious interest is to praise credit where he himself believes it to be due for the various features of electric furnace design and practice. To this end many references are made to the patent literature. It is at times that Prof. Borchers occasionally greatly overrates the importance of his own experimental work in the development of the art, as he is led to claim for himself the credit of many inventions which are usually attributed to others.

The great industrial usefulness of the electric furnace in its numerous forms would justify the existence of text-books dealing with the subject even if the art had not advanced beyond the stage of infancy, and it will be an encouragement to electric furnace progress when an authoritative work appears which treats of the design, construction, operation and scientific principles of furnaces from the [illegible] point of view.

In this respect the details given in Dr. Borchers' book on electrode construction and connections will be found very useful, although the immense possibilities of artificial graphite are not even noticed. But it can hardly be claimed that this volume presents a complete analytical study, since power factors of alternating-current furnaces are not mentioned, constructive materials are not discussed from the standpoint of electric and heat conductivity and refractory qualities, and costs of furnaces and furnace operation are not dealt with. Nevertheless, many experimental details given in Dr. Borchers' book will be found useful, representing first-hand information, based on the author's own experience. In this fact rests the chief value of the book. As an analytical study of electric furnaces it is inferior to Prof. Stansfield's work. But as long as we have not yet all the information that is useful or even necessary, collected in a single volume, Borchers' book deserves a place at the side of Moissan's and Stansfield's works in the library of electrochemists.

The translation is, in general, satisfactory. But there are small slips or ambiguities which give the style at times somewhat of a sloppy appearance. Thus on page 1: "The heat developed must be equivalent to the work EC, if during the passage of a current of C amperes through a length of conductor the e.m.f. consumed be E volts." EC is not work, but power, and the sentence should read: "The heat developed per second must be equivalent to the power EC." On page 2 it is said to be self-evident that "in conductors of the same material, both the resistance *and the heat produced* increase with increasing length. . . ." But this is true for the heat produced only if the current is maintained constant; it would be quite different with constant impressed e.m.f. On page 3 it should be clearly stated that the four temperatures of wires calculated are those which the conductors would have after t seconds if no heat was conducted away or radiated. And so on. We also noticed some misprints. The statement on page 211 that a kilogram is approximately 1½ lb. (instead of 2.2 lb.) is a bad example.

If the translator would adopt FitzGerald's term "resistor" for the material or substance which offers a resistance to the passage of an electric current, many passages in the book would become smoother reading. Since Mr. FitzGerald proposed this term in our columns three years ago, it has been quite generally adopted in this country.

* * *

Principles and Practice of Agricultural Analyses. Vol. II: Fertilizers and Insecticides. By Harvey W. Wiley, A.M., Ph.D. 650 pages. Price, $4.50 net. Easton, Pa.: Chemical Publishing Co.

It is a pleasure to take up this book, and Dr. Wiley has certainly placed the chemical world in general, and agricultural chemists in particular, under great obligations. The work has been brought quite up to date; a great part of the material relating to the occurrence and analysis of ammonia, nitrous and nitric acid, printed in Vol. I, has been rewritten and transferred to this volume, thus making the first and second revised volumes about the same size. The paper devoted to the description and manufacture of calcium cyanamide and the fixation of atmospheric nitrogen, will be of interest to our electrical friends in Niagara Falls, where a plant for the manufacture of calcium cyanamide is now being built.

The book is divided into four parts; part one dealing with methods of sampling, statistics, composition and analysis of phosphates; part two with the nitrogen in fertilizers, drainage waters, the utilization of the nitrogen of the air and methods of determining nitrogen and nitric acid; part three with potash in fertilizers, organic sources of potash and method of analysis and determination of potash; and part four with the classification and description of miscellaneous fertilizers, insecticides and fungicides.

Very complete references are given and the index is good.

Electrochemical and Metallurgical Industry

VOL. VII. NEW YORK, FEBRUARY, 1909 No. 2.

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH. D.....*President*
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C. E. WHITTLESEY.....*Treasurer*

Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, FEBRUARY, 1909.

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National Chemical Societies.

During the week between Christmas and New Year American chemists and chemical engineers inclined to attend chemists' conventions were kept busy. The American Institute of Chemical Engineers held its first annual meeting on Dec. 28 and 29 in Pittsburgh. The American Chemical Society began immediately afterward, in Baltimore, its thirty-ninth general meeting, which lasted to Jan. 1. Both meetings—accounts of which will be found elsewhere in this issue—were decidedly successful. The Baltimore meeting was exceedingly well attended. Not much less than 500 chemists were present, and there was much rejoicing in the new spirit of activity manifest in the American Chemical Society. The society has grown rapidly during the last years, but developments in various directions clearly indicated the necessity to do something out of the old ordinary ways in order to hold together successfully the membership steadily growing in number and heterogeneity. Hence the new policy of decentralization with the formation of special sections, like that of industrial chemistry, with its own well-edited journal. Any special brand of chemists may now find a certain limited degree of recognition and furtherance within the American Chemical Society under its new benevolent paternal policy. It is not fair to deride this new policy as a lucky afterthought and the new spirit of progressive activity as forced upon the society by outside developments ("Du glaubst zu schieben und du wirst geschoben"). Even though there is some truth in this, the new spirit must be recognized to exist, and the congratulations which were showered by the membership at large on the members of the council of the society at the Baltimore meeting were well deserved.

* * *

The Pittsburgh meeting of the American Institute of Chemical Engineers was awaited with considerable interest, since it was the first general meeting of the Institute and the record made at this meeting would have a decided influence on its future development. As we said already, the meeting was a full success. Naturally, with respect to attendance, this meeting could not stand any comparison with the Baltimore meeting of the American Chemical Society. But such a comparison would be wholly unfair. The Institute of Chemical Engineers is planned to be not so much a society open to all interested in its field, but rather something like a national club, restricted in membership and comprising men of the same professional type. Dr Sadtler's presidential address made out a very good case for the formation of the Institute, and the excellent program of papers proved conclusively that chemical engineering is broad and diversified enough to combine in a common organization men of varied interests but with a common broad engineering viewpoint, and to offer something new and interesting to all of them. The broad viewpoint was the characteristic signature of the meeting as a whole and of the different papers. It must be emphasized again and again that chemical

engineering is broader than industrial chemistry, since the chemical engineer enters with his way of thinking and looking at things into every field of engineering activity, and his work is by no means restricted to the chemical industries. That there may be even a clash between the views of the chemical engineer and of the industrial chemist, was clearly borne out by Dr Brewster's interesting paper on the sanitary condition of the southern end of Lake Michigan, since the chemists of the glucose factory in question, if they are nothing more than industrial chemists, will hardly like the conclusions of the author who spoke as a chemical engineer.

* * *

The whole first session was devoted to the various problems which the chemical engineer has to solve in a boiler plant. Dr. Gudeman took an excellent common-sense view of what the boiler-plant proprietor wants and needs when he has his coal tested by a chemist. Mr. Booth discussed the possibilities of reducing the different losses in a steam power plant. Mr. Greth dealt with the related subjects of scale formation and corrosion in boilers. Dr. Hunicke used the results of the boiler tests of the U. S. Geological Survey to discuss a very interesting problem—namely, to determine the complete history of a combustion process from the analysis of the fuel and of the flue gases. While the result of Dr. Hunicke's investigation is chiefly negative, it should have a profound positive effect on engineers making such boiler tests in future. Flue gas analysis is a very useful method which can often give valuable information on the way in which a process is carried out; and it is a method to which still insufficient attention is paid in many cases. For instance, in all experiments on the reduction of iron ores in the electric furnace it is of great importance that such gas analyses should be made.

* * *

Mr. Meade in his paper on the use of pulverized fuel for industrial purposes took up a subject that should interest many chemical and metallurgical engineers. The possibilities of the different methods of firing furnaces are not yet as fully understood as they could and should be. It is a remarkable fact that producer gas for firing industrial furnaces is much less used in this country than abroad. The knowledge of the possibilities of pulverized fuel is even still more restricted; while it is predominant in the Portland cement industry, it is practically unknown outside of this industry. From Mr. Meade's paper it would appear that this is a subject that should be carefully considered by metallurgists. While pyrometers were known chiefly to scientific men only a few years ago, we have witnessed during the last years a decided pyrometer boom in many industries and there are all indications that this boom is going to last. We have also had many papers on pyrometers, chiefly descriptive of the different principles and constructions. Dr Northrup's paper was a welcome exception from the rule, dealing broadly and most instructively with electric resistance pyrometry from the viewpoint of the user. Low-temperature work was touched incidentally at the meeting by the paper of Dr Fraenkel on liquid ammonia. Mr. Thorn Smith's paper covered an interesting controversial point of the theory of the contact process of making sulphuric acid. Finally, Dr. Grosvenor's paper on dryer design was an excellent proof of the rule that the chemical engineer must base his calculations and designs on a broader foundation than pure chemistry. Chemical engineering must be applied physical chemistry. These were the papers actually presented at the meeting, the balance being read by title. This indicates a lack of time, as is the common experience of all societies. The American Institute of Chemical Engineers may find it advantageous to have its papers printed and distributed to its members in advance. With its restricted membership this would not be impracticable, and since the papers are to be printed anyway, the cost would not be prohibitive. This practice would save valuable time in the presentation of papers, but, above all, it is the best and only method to get out a good discussion.

* * *

In addition to the American Chemical Society and the American Institute of Chemical Engineers, there is the American Electrochemical Society, now seven years old and rapidly growing in membership and prestige. In all we have, therefore, now three national chemical societies in this country. But the field is so broad that there is open for each of them a career of usefulness and activity, with glory enough for all. Though independent, they all could and should coöperate in a fine liberal spirit to promote the common interests of chemistry, each in its own sphere of influence. It is high time that narrow jealousy should cease. It should no longer be possible or practicable for a distinguished industrial chemist to rise in an important committee meeting with the complaint that electrochemical engineers and inventors get all the public recognition and the "poor pure chemists" get nothing. Those overzealous members of the American Chemical Society who even now, again and again, bring forward the suggestion of absorbing the Electrochemical Society, should finally learn that such a scheme is, to put it mildly, an anachronism. And the formation of the American Institute of Chemical Engineers should also be taken as an accomplished fact; the American Chemical Society can find no better friends than among the founders of the Institute. It is all very well to speak of the tendency of the times to form commercial combinations and trusts for manufacturing on a large scale. But science, pure and applied, is promoted not in such a way. What counts here is individuality, the man as man. Great advances are made by opposing individualities. For the promotion of science and engineering, even in a limited field like chemistry only, nothing could be worse than the combination of the various scientific and engineering societies into one unit, with one publication committee and an editor in charge who as a practical dictator would determine what is suitable for publication and what not. It is unnecessary to add another word.

Detinning of Tin Scrap.

The rapid growth of the tin plate industry has brought with it the problem of detinning the tin scrap left useless in tin can factories; an even more important commercial problem is the detinning of the old used tin cans. From an engineering standpoint the former problem is immensely easier than the latter. The tin scrap of the factories is a pure starting material, consisting of nothing but steel and tin, while the used tin cans contain all kinds of impurities, so that in this case a complicated preliminary purification is required. The paper of Dr. Karl Goldschmidt, found elsewhere in this issue, gives a clear and concise sketch of the history of the detinning industry.

The author is pre-eminently fitted to write this sketch, since he and his brother, Dr. Hans Goldschmidt, of thermit fame, founded the detinning industry, first developing the electrolytic detinning process and during the last years chlorine detinning. The products of the former are steel and tin; in the average it may be said that the value of the detinned steel sold to open-hearth plants is about as much as the value of the tin recovered. The products of the chlorine detinning process are steel and tin tetrachloride; the latter has a ready market in silk mills. It is interesting to note that the chlorine detinning process has proven commercially so much superior to the old electrolytic process that after successful working of the latter for many years at the Goldschmidt works in Essen (treating yearly 50,000 tons), it has now been completely supplanted by the chlorine process; for a time both processes had been used side by side at these works, to compare them carefully.

* * *

While the electrolytic detinning process thus appears to be doomed, another electrolytic process will gain by this change. This is the production of caustic soda and chlorine by electrolysis of common salt. From a commercial point of view, the caustic soda had always been the better half of the process, as it finds an easy market with reasonable prices. The utilization of the chlorine, on the other hand, has met with difficulties, and some manufacturers would have preferred to let it pass off into the atmosphere had that been possible without damage suits. The chief product made from chlorine has always been bleaching power. But while the amounts of caustic soda and bleaching powder produced in this way are chemically equivalent, the commercial demand for both products does not agree with this chemical equivalence. The obvious result was overproduction of bleaching powder and low prices. Hence the continuous endeavor of the producers of chlorine to find new uses for it. One successful outcome of these endeavors is the chlorine detinning process, and it is significant that for its development the possibility of liquefying chlorine cheaply was of importance. It is very probable that when liquid chlorine becomes commercially available in this country, other advantageous applications of chlorine may be developed.

The United States Geological Survey.

The report of the United States Geological Survey for 1908 shows in an interesting way the growth of the scope of its work in recent years. Beginning in 1879 with an appropriation of $100,000 for the classification of the public lands and the examination of the geological structure, mineral resources and products of the public domain, the duties imposed by Congress on the Survey have steadily grown, until its field of operation covers now the whole country, including Alaska. Simultaneously, the appropriations have grown; in 1908 they amounted to $1,782,770. The name "geological survey" really no longer fits the work, as it is no longer restricted to the science of geology and the study of ore deposits. Other matters, like mine explosions and rescue work, the prevention of waste, the testing of building materials, etc., now form an important part of the Survey's work and publications. As to the primary work of the Survey—the preparation of a geologic map of the United States—the report states that geologists have been at work during the year in many of the Eastern States, from Maryland to Texas, investigating the distribution of the rock formation and correlating the underground water-bearing beds. During the last field season 26,994 sq. miles of topographic mapping were completed. Extensive work has also been done in the oil fields, and it has become evident that one of the greatest needs of the petroleum industry is a general chemical examination, by uniform methods, of all the crude petroleums of the United States.

* * *

Those new investigations mentioned above as being beyond the original scope of the work of the Survey were mainly carried out by its Technologic Branch. A notable event was the opening of the Pittsburgh experiment station for the purpose of investigating the causes of mine disasters. One of the results obtained there is the proof that coal dust is as dangerous an explosive as firedamp. It is proposed by the Survey to standardize commercial explosives so as to get a definite idea of what each charge of powder will do. A special and somewhat spectacular feature of this experiment station is a gas-filled room in which miners equipped with oxygen helmets are being trained in rescue work. At the structural materials laboratories at St. Louis the tests of the strength of the different materials of construction and of the fire-resisting qualities of these materials were continued. At Pittsburgh a laboratory has been established for investigating the chemical and physical properties of clays and clay products. Finally, the work at the different fuel-testing plants must be noticed. At Pittsburgh successful experiments with very poor coals have been made, while at Denver it has been shown that practically all the coals of the Rocky Mountain fields yield coke suitable for metallurgical purposes. The work of the fuel-testing plants is very important. Dr. Hunicke, in his paper before the American Institute of Chemical Engineers, printed elsewhere in this issue, offers some important criticisms of the flue-gas analyses made in this work of the Survey. It seems desirable that the Survey give more attention to the chemistry of the problems investigated. Perhaps the general criticism is justified that these newer technological investigations of the Survey are not yet up to the mark in every respect from a scientific standpoint. But this is no good reason to condemn the extension of the scope of the work of the Survey.

Sampling and Analysis of Iron Ores.

In this issue we print the complete official account of the methods of the United States Steel Corporation for the commercial sampling and analysis of iron ores. This report was prepared by a specially appointed Chemists' Committee, with Mr. J. M. Camp, chief chemist of the Duquesne works of the Carnegie Steel Company, as chairman. The preparation and publication of this report is the outcome of the natural desire of the U. S. Steel Corporation to standardize their methods of sampling and analysis. The question arose how far to go in standardization. In the description of the methods of analysis the idea of the Committee was evidently to outline, in a general way, the procedure without too close attention to the details, leaving these to the chemists themselves. This was probably a wise policy. The report should attract careful attention, both for the eminence of the source from which it emanates and for the great care which has evidently been taken in its preparation

Baltimore Meeting of the American Chemical Society.

The meeting of the American Chemical Society, held simultaneously with the American Association for the Advancement of Science in Baltimore from Dec. 29 to Jan. 1, was more largely attended than any previous meeting of the society, and was unusually enthusiastic.

The local committee had made special arrangements for the entertainment of the visiting chemists, consisting of banquet and smoker, automobile rides, parties and dinners for the attending ladies, and excursions to Annapolis, to the Maryland Steel Company's works, to the various Baltimore breweries, to Sharp & Dohme's works and to various points of interest around the city.

Some 425 chemists were present and attended the various sectional meetings of the society, besides addresses given in general session.

These general addresses have proved a very attractive feature of recent meetings. Those delivered at Baltimore were:

The Untilled Field of Chemistry, A. D. Little.

The Use and Abuse of the Ionic Theory, Gilbert N. Lewis.

The Work of Werner on the Constitution of Inorganic Compounds, Charles H. Herty.

The Future of Agricultural Chemistry, H. J. Wheeler.

The Quantitative Study of Organic Reactions, S. F. Acree.

The Classification of Carbon Compounds, Edward Kremers.

The Efficiency and Deficiencies of the College-Trained Chemist when Tested in the Technical Field, William H. Nichols.

To What Extent Should College Training Confer Practical Efficiency Along Technical Lines? Louis M. Donnie.

The Attitude of Technical Institutions to Post-Graduate Study, William McMurtrie.

To these should be added the addresses of President M. T. Bogert, of the American Chemical Society on "The Function of Chemistry in the Conservation of Our Natural Resources," and of H. P. Talbot, vice-president of Section C of the American Association for the Advancement of Science on "Science Teaching as a Career."

Over 160 papers were announced and read before the nine different sections into which the meeting was divided. The recently organized Division of Industrial Chemists and Chemical Engineers was in session on four separate days. Notable papers presented before this section were by E. G. Bailey on "Accuracy in Sampling Coal," and by W. H. Walker on a new method of quickly finding imperfectly covered spots on tin plate.

The following divisions were officially authorized and have organized and elected officers: Division of Physical and Inorganic Chemistry; Division of Agricultural and Food Chemistry; Division of Organic Chemistry; Division of Fertilizer Chemistry.

The Iron and Steel Market.

January has not fulfilled expectations in the iron and steel trade. A continuance of the progressive improvement which characterized the second half of last year was expected, and the more sanguine were disposed to look for an increase in the rate of improvement. The outcome has been in the contrary direction. Most producers have found materially less business in January than they did in December, and in many branches of the trade the market has been extremely dull.

As a whole, the railroads are probably buying as liberally as they did in the closing months of 1908, but there is that character of their buying which does not promise much for the first half year at least. In rails, for instance, the orders as a rule are for small tonnages and for early delivery. Such orders indicate that, as was expected, some railroads have got to a point where they cannot longer defer replacement of worn out rails, but it was not expected that when railroads should reach this point they would buy in such small quantities. Some steel car orders are being placed, which make a not altogether insignificant tonnage, but it is patent that it is only an occasional road, particularly well fixed financially, or particularly short of rolling stock which is buying. That the rail tonnage is quite insufficient to the capacity may be illustrated by a couple of instances. The Pennsylvania system did not place any regular order for 1908 on account of the dispute as to specifications, so that its order for 1909 should have been particularly large. It amounted, however, only to 135,500 tons, less than the average for several years preceding 1908. The Edgar Thomson mill is working on its allotment of the Pennsylvania order, deliveries to be completed by May or June, and yet is running only to 35 per cent or less of its capacity. The Chicago rail interest, which must also take care of the new Gary plant if it runs, has been booking only a few thousand tons a week, although having a capacity of 40,000 or 50,000 tons a week to take care of.

In the lighter lines, which showed such a steady run of business last year, most of the accounts are unsatisfactory. The wire trade has been doing best of all, and is running at between 60 and 75 per cent of capacity. Pipe has been quiet, and sheets have not been doing as well as toward the close of last year. Tin plate has been quiet, but the mills entered the year with a good volume of business on books, and are more than holding their own as to operations. In bars specifications have decreased somewhat and new business is extremely light.

PIG IRON.

The month has been the dullest in pig iron for a long period. There has been a fair measure of activity in low-grade iron, particularly Southern, for pipe works. Foundry iron has been extremely dull in all markets. Bessemer in the Central West has been dull, and has shown a decided weakness in price besides. A few good transactions in basic have been made in the East, while in the Central West nothing of importance has been done since the Pittsburgh Steel Company's purchases, amounting to about 20,000 tons, for first quarter, were made late in December. Prices on the whole have been well maintained, but the market has not been seriously tested and it is not altogether certain that they can be maintained through a continuation of this dullness. The temper of the trade is evidently that there is more prospect of a recession than of an advance. The annual question of Lake Superior ore prices is about to engage the attention of the trade, and the question comes up under rather unfavorable auspices this year, on account of the naming of 1907 prices in February of last year and the subsequent 50-cent reduction in June. Previous to that experience the merchant ore interests had maintained the reputation of adhering to prices, once announced, through the season. Last year they were led by extraneous influences into a premature announcement.

December pig iron production showed a heavy gain over November, and the rate of production on Jan. 1 was still higher, being close to 21,000,000 tons a year. January production may equal that of December, but there seems to be no dissent in any quarter from the generally expressed view that the slackness in new business in January must force a lower rate of production within a short time. Already there has been a material increase in stocks at furnaces, and in some isolated instances nearly the entire January output has gone into stock piles.

There has been no distinct change in quotable prices except that in all districts there has been a withdrawal from the position of asking a 25- to 50-cent advance for second quarter delivery over first quarter. In all districts there are furnaces ready to do first-quarter prices for second-quarter delivery, while first-quarter prices are not quotably changed. Bessemer iron is nominally unchanged at $16.50, valley, but is very weak at this price. Otherwise prices quoted are understood to be well maintained, although the market is not being seriously tested. We quote as follows: Philadelphia, $17.25 to $17.50 for No. 2 X foundry; f.o.b. valley furnace, No. 2 foundry, $15.50; basic,

$15.50; Bessemer, $16.50; forge, $14.25; Chicago No. 2 foundry $17 at furnace, or $17.35 delivered, meeting delivered prices on Southern iron; the South, $13, Birmingham, for No. 2 foundry.

BILLETS AND SHEET BARS.

In the East there is more disposition to shade the regular delivered prices, there being several producers open to negotiation on desirable tonnages, but very little business has come up In the Central West regular prices are understood to be maintained, these remaining on the basis of $25 for billets and $27.50 for sheet bars, Pittsburgh.

FINISHED MATERIALS.

While shading in one finished steel product or another was not absent at any time last year, there is probably more shading now than at any previous time. Shapes, plates and sheets are being shaded more or less, perhaps only by $1 or $2 a ton in the case of sheets, but by more than this in the case of shapes for important structural contracts. Light rails are easier, selling at $22 to $23, the official price being $25. Official prices remain as follows, being f.o.b. Pittsburgh, with the exception of rails, which are f.o.b. mill:

Standard rails, $28 for Bessemer; $30 for open-hearth.

Plates, 1.60 cents for tank quality.

Shapes, 1.60 cents for beams and channels, 15 in. and under, angles and tees.

Steel bars, 1.40 cents; iron bars, 1.50 cents, delivered Pittsburgh or Chicago.

Plain wire, 1.80 cents; wire nails, $1.95.

Sheets, 2.45 cents, net, for black; 3.50 cents, net, for galvanized, 28 gage.

Tin plates, $3.65, net, for 100-lb. cokes.

An Alleged Patent Fraud.

On Jan. 12 the grand jury at Lockport (the county seat of Niagara County, New York) found four indictments against Mr. Charles E. Acker, of the late Acker Process Company, of Niagara Falls, one of the indictments being for perjury, the other three for subornation of perjury.

The case is the outcome of a patent interference case on a process of detinning by means of chlorine, between Dr. Karl Goldschmidt and Dr. Joseph Weber, of Essen, Germany, on one side, and Mr. Charles E. Acker on the other side.

The two patents of Goldschmidt and Weber of importance in the case are No. 822,115 of May 29, 1906, and No. 831,223 of Sept. 18, 1906. Full abstracts of these patents were given on pages 328 and 419 of our Vol. IV (1906), while a statement concerning the formation of the Goldschmidt Detinning Co., which will operate under these patents in this country, will be found, together with a review by Dr. Karl Goldschmidt of the whole detinning industry on page 79 of this issue.

In view of the publicity which the perjury charge has found in the public press, we give below concise statements of all parties.

* * *

According to the indictments, the alleged perjury was committed by Mr. Acker in swearing that he reduced the invention of the Goldschmidt patent 831,223 to practice in the early part of December, 1902; the alleged subornation of perjury was committed by inducing three men to testify that they had helped Mr. Acker in these experiments, while, it is alleged, these experiments were not made at all.

* * *

According to a statement given to the press by Mr Hubert E Rogers, of counsel for Drs. Goldschmidt and Weber, the situation is as follows: To Goldschmidt and Weber a patent was granted (No. 822,115) on May 29, 1906, on a process for removing tin by means of chlorine gas from tin scraps, and a further patent, on Sept. 8, 1906 (No. 831,223), on a modification of the same process. It is alleged that within three weeks after the issue of the first patent Acker filed an application in the patent office covering the same subject as that of the patent, that within three weeks after the issue of the second patent he filed an amendment to this application which contained, word for word, as well as the punctuation, 14 of the 16 claims of the latter, and then applied for interference proceedings.

Under the United States patent laws a foreigner is limited in date of invention to the date on which a corresponding patent in his own country was published, while a domestic inventor can prove the date of his invention by testimony. Goldschmidt and Weber's date was March, 1905.

In the interference proceedings Acker stated that early in December, 1902, he first made use of his idea by a practical demonstration of it in the laundry tubs in the laundry of his house in Niagara; that he continued his experiments on an average of at least once a week at the same place until Christmas of 1902, and thereafter in the basement of the works of the Acker Process Company, at Niagara Falls, until April or May, 1903, after which the apparatus was returned to the cellar of his home, where he worked on the invention at least once a week until February, 1906.

Four witnesses were called to support this statement all former employees of the Acker Process Works.

The lawyers of Goldschmidt and Weber state that in investigating this testimony they located practically all of the servants who had been employed by Acker at his residence during the period covered by the operations described by him, and that none of them knew anything of any detinning or chemical operations having been conducted in the laundry. It is alleged that attempts were then made by Acker to influence these witnesses in giving testimony, and complaint was made to the district attorney of Niagara County. It is alleged that after having heard the stories of these witnesses, the district attorney sent for the three young men who had given testimony to the effect that they had assisted Acker in the operations in the laundry, and questioned them, and that as a result each of them broke down and confessed that his story was false from beginning to end, whereupon application was made to the Patent Office at Washington to have the case (which had then been closed) reopened, and the Patent Office granted this request, reopened the matter, and these three witnesses were again put on the stand and testified that their testimony formerly given was false throughout

It is stated that thereafter the interference case came on for hearing before the Patent Office authorities, and judgment was rendered in favor of Goldschmidt and Weber against Charles E Acker on Oct. 13, 1908. Limit of appeal having elapsed, a further and final judgment was rendered in the interference case against Charles E Acker on Nov. 2, 1908.

* * *

Mr. Charles E. Acker makes the following statement

"This prosecution grows out of a litigation concerning certain patents or applications owned by the Tin Products Co., of New York, relating to a process of detinning, the parties to which were Goldschmidt and Weber, of Germany, upon the one side, and myself on the other.

"The witnesses whom it is claimed I induced to testify falsely in that litigation were examined at great length and in the minutest detail in a public hearing in which both parties were represented by attorneys, Mr Dane, of New York, representing Goldschmidt and Weber, and Dr. Byrnes, of Washington, representing myself, and some time after their testimony had been given they were induced, by some means, to go, again, upon the stand and testify that they had sworn falsely in some particulars and had been induced to do so by me.

"It developed that the attorneys for Goldschmidt and Weber had pressed the district attorney of Niagara County into their service and that he had required the presence of these witnesses at his office and obtained from them statements to the effect that their testimony was false, and had then immediately turned over these affidavits to the attorneys for Goldschmidt and Weber for use in the litigation This occurred about seven months ago. Many grand juries have convened in Niagara County during

seven months and these charges have not been presented by the district attorney until now. The fact that the district attorney first procured these witnesses to say that they falsely testified, that he turned over their statements to the attorneys for Goldschmidt and Weber for use in the litigation; that he has permitted seven months to elapse without making any move toward a judicial investigation of the charge against me and that he now acts only upon the request of the attorneys for Goldschmidt and Weber, and that he refused to permit my side of the case to be heard before the grand jury are circumstances which seem to call for an explanation and characterizes this prosecution as an effort to advance the interests of one of the parties to a civil litigation rather than as a performance of a public duty.

I can only say that I am guiltless of the charge made against me, and I feel sure that when I am accorded a fair hearing that I will be vindicated."

Pure Food Law.

While going to press it is reported from Washington that the "unofficial" referee board of chemists appointed by President Roosevelt has decided that benzoate of soda used in food as a preservative is not harmful and deleterious to human health. In this position the board flatly joins issue with Dr. Harvey W. Wiley, Chief of the Bureau of Chemistry of the Department of Agriculture, who held that benzoate of soda is harmful.

The referee board was appointed last March and consists of Dr. Ira Remsen, of Johns Hopkins University; Russell H. Chittenden, of the Sheffield Scientific School of Yale; John H. Long, of the medical school of Northwestern University; C. A. Herter, of the College of Physicians and Surgeons, Columbia University, New York, and Alonzo E. Taylor, of the University of California. Dr. Taylor has been absent in Europe and has not participated in the consideration of the question. Otherwise the report of the board is unanimous.

The referee board reached its conclusion after experimenting on a "poison squad." Dr. Wiley also reached his conclusion after experimenting on a "poison squad." In presenting the issue the President submitted to the board two propositions, as follows:

1. Does food to which there has been added benzoic acid or any of its salts contain an added poisonous or other added deleterious ingredient which may render the said food injurious to health? In large quantities? In small quantities?

2. If benzoic acid or any of its salts be mixed or packed with a food, is the quality or strength of said food reduced, lowered or injuriously affected? In large quantities? In small quantities?

The main general conclusions reached by the board are:

First—Sodium benzoate in small doses (under 0.5 gram per day) mixed with the food is not deleterious or poisonous, and is not injurious to health.

Second—Sodium benzoate in large doses (up to 4 grams per day) mixed with the food has not been found to exert any deleterious effect on the health nor to act as a poison in the general acceptation of the term. In some directions there were slight modifications in certain physiological processes, the excess signification of which modifications is not known.

Third—The admixture of sodium benzoate with food in small or large doses has not been found to injuriously affect or impair the quality or nutritive value of such food.

CORRESPONDENCE.

Heat Conductance Through Furnace Walls.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—Your January issue, page 8, contains a reference to my recent paper by an engineer in Denver. I appreciate his complimentary remarks, but I think he has misunderstood me in some of his statements.

The paper states clearly that it refers only to one part of this calculation and not to a determination of the conductivity constants. The latter are supposed to be looked up in tables. The result, of course, will be no more accurate than these constants are; but, on the other hand, if made as I described, these calculations will not increase the inaccuracy as they did in the former and more usual methods. It was hoped that a greater possible accuracy in this one part of the calculation would lead to more accurate redeterminations of these conductivity constants; in fact, one object of my paper was to stimulate the interest in such redeterminations. Moreover, the results of my deductions have pointed out a new and simple method of determining these constants with much greater accuracy than heretofore.

Your correspondent is in error when he virtually says that these calculations are of little use for predetermining the loss in a new furnace, until these constants have been redetermined. Many of these constants are contained in tables, and many have been published in this journal. These can well be used and, in fact, have been used by myself and doubtless by many others for new and old types of furnaces. The fact that they are less accurate than the calculations which I described, is no good reason why they should not be used, nor why my determinations are not practicable.

PHILADELPHIA, PA. CARL HERING.

Proposed Court of Patent Appeals.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—It might interest your readers to know that before the sixtieth Congress, first session, a bill has been introduced in the House of Representatives by Mr. Currier, the number of which is H. R. 21,455. Copies can be obtained from United States government by applying to their representatives. This bill is called "A Bill to Establish United States Court of Patent Appeals and for Other Purposes."

If this bill is passed it will do away with the grievous conditions that exist now in patent decisions before the Circuit Courts. The bill has been favorably reported upon, as will be seen by reading the arguments before the Committee on Patents of the House of Representatives, March 18, 1908, number H. R. 14,047.

All chemists, all engineers, all inventors, as well as the public at large, are interested in this subject and it is very desirable that this bill should pass.

Those who are willing to aid in this work are requested to write letters to the House and Senate favoring its passage. Write first in order of preference to members of the House Judiciary Committee and then to the members of the Senate Committee on Patents.

YONKERS, N. Y. L. H. BAEKELAND.

[The Senate Committee on Patents consists of Senators Reed Smoot, of Utah; William H. Milton, of Florida; Frank B. Brandegee, of Connecticut; Alfred B. Kittridge, of South Dakota; Murphy J. Foster, of Louisiana; Moses E. Clapp, of Minnesota, and Frank B. Gary, of South Carolina. The Committee on Judiciary of the House of Representatives consists of Representative John J. Jenkins, of Wisconsin, chairman; DeAlva S. Alexander, of New York; Charles Q. Tirrell, of Massachusetts; John H. Foster, of Indiana; Ruben O. Moon, of Pennsylvania; George R. Malby, of New York; David A. De Armond, of Missouri; Robert L. Henry, of Texas; Charles C. Reid, of Arkansas; Richard Wayne Parker, of New Jersey; Charles E. Littlefield, of Maine; John A. Sterling, of Illinois; Henry T. Bannon, of Ohio; Garrit J. Dickman, of Michigan; Henry S. Caulfield, of Missouri; Henry D. Clayton, of Alabama; William G. Brantly, of Georgia, and Edwin T. Webb, of North Carolina.]

Pittsburgh Meeting of the American Institute of Chemical Engineers

The first annual meeting of the American Institute of Chemical Engineers was held in Pittsburgh, Pa., on Dec. 28 and 29.

All the sessions devoted to the reading and discussion of papers were held in the lecture hall of the Carnegie Technical Schools. Simultaneously an exhibition of various chemical engineering apparatus and machinery was held in the basement of the same building. A complete account of this exhibition will be found on pages 89 to 92 of this issue.

Professional sessions were held on Monday morning and evening and on Tuesday morning and evening. The afternoons had been reserved for excursions to the Duquesne plant of the Carnegie Steel Company, to the works of the Westinghouse Machine Company and to the U. S. Government Explosives Testing Laboratory in Pittsburgh. On Dec. 30, after the official close of the meeting, various members made an excursion to the by-product coke works of the Carnegie Steel Company, at South Sharon, Pa.

The Institute has at present 88 members. All the officers which had been elected at the organization meeting at Philadelphia last June were re-elected (see our Vol. VI, page 272).

Since we comment on our editorial pages on the undeniable success of this first general meeting of the Institute, this report will go at once in medias res. In the following we give abstracts of the papers presented; the papers will be printed in full in the *Proceedings* of the Institute.

* * *

The first session on the morning of Dec. 28 was opened by a speech of welcome from the Carnegie Technical Schools, to which the president of the Institute, Dr. Sam. P. Sadtler, replied. He referred to Pittsburgh as a pre-eminent center of chemical activity and to the Carnegie Technical Schools as a typical example of the kind of schools we wish to see developed.

During the morning session papers were read by Messrs. Gudeman, Booth, Greth, and Hunicke.

Technical Coal Analysis.

The first paper was presented by Dr. Edward Gudeman, of Chicago, on technical coal analysis, especially for such works where the maximum daily consumption does not exceed 50 tons of coal per day. This includes at least two-thirds of all stationary steam-boiler plants in the United States.

The operating forces of such plants are not of exceptional skill, and about all the information one can get in such plants is the cost of coal per ton and what they believe has been their daily or annual consumption. The cost figures are generally correct, but the amount used may be within 10 per cent of correct, as in very few cases the coal is weighed in, in fact, even at plants with a daily consumption of up to 500 tons, Dr. Gudeman has seen the capacity of cars taken as the amount of actual delivery.

What is now the purpose of technical coal analysis for such plants? According to Dr. Gudeman, the object of any technical analysis is two-fold: First, to judge the product itself, and, secondly, to give to the consumer information as to the value of the product. This valuation can be directly in dollars and cents, compared with a standard product used for same or similar purposes, or in terms of efficiency for actual usage

Applying these objects to the technical analysis of coal, used for steam production, valuation should be as to what the coal is worth in dollars and cents based on its efficiency, under the specific conditions in which it is used, that is, the report of analysis should give its evaporation power and figure the cost of the steam made per unit of coal used.

Dr. Gudeman thinks that technical coal analysis, as now generally carried out, comprises too many unsuitable determinations, while the results are given in a few detailed figures, which the manufacturer, for whom the report is made, does not understand. The thermal units are made the whole show and the value in the coals is given in B.t.u's., generally with heavy type, but using the initials only, as that makes it look more mysterious.

Our present-day determinations consist of the determination of water, occluded gases (air) and direct determination of hydrogen, nitrogen, oxygen, possibly carbonic oxide and acid, also the sulphur, phosphorus, iron, silica, lime and sometimes mineral matter, and sometimes ash.

The thermal heat units are determined one way or the other, preference being given to this or that piece of apparatus, based mainly on the experience of the analyst with his favorite apparatus. If he gets good duplicate results, he is satisfied and swears by that apparatus. If his results do not duplicate, due to inexperience, carelessness or ignorance, the apparatus is at fault and "n. g." The author has heard one very good instrument very severely criticized because it gave abnormal results if glass was ground in with the coal.

In present reports the value of the coal is mainly based on thermal units and these are reported, first, for the coal as delivered, then for the cool air dried, then for the coal kiln dried (drying in bath), then the same calculations are made for coal ash-free, ash-and-sulphur-free, ash-and-sulphur-and-gas-free, and so on.

Dr. Gudeman continued pertinently: "This is a sort of house that Jack built, and I expect before long some one will make correction for argon and another will take radium or other emanations into consideration, while others will apply the ionic theory or make correction for dissociation due to something or other."

What the consumer wants, and should get, is what the coal is worth, and he should get this in the simplest and most concise form, in such a form that he can interpretate the results and compare the different reports and value his coal.

The requirements for quantitative coal analysis during Dr. Gudeman's student days were to determine water, volatile and fixed carbons, ash and sulphur. And it is a fact that these determinations are sufficient for all practical purposes to value and grade coals, and that the b.t.us. calculated therefore are as close as and generally much closer than the direct calorific tests when applied to actual results obtained in burning the coal under the boilers. For this calculation of thermal units Dr Gudeman uses an empirical figure of 13,500 B.t.u's. for fixed carbon and 16,500 for volatile carbon.

He determines the water in coal, or what he calls water, by drying in the hot-air bath for one hour at 105° C. He uses a platinum crucible and 2 grams of substance. For very wet coal he dries first on the water bath for one-half hour. After the water is obtained by loss, the crucible is heated 2½ minutes over direct Bunsen burner and then 2½ minutes with blast. This loss is the volatile carbon. The fixed carbon is then burnt off by direct flame over Bunsen burner, and the residue is the ash. Sulphur determination is made on a separate sample using the mixed carbonate and nitrate fusion, taking at least 15 grams of fusion mixture, 2 of carbonate to 1 of nitrate to every 1 gram of coal.

If the B.t.u's. are determined direct and calculated to the water-, ash-, sulphur- and gas free coal, what are they calculated to? Why all that is left is the volatile matter (volatile carbon) and the fixed carbon (coke). All errors are thereby thrown on the errors of determination of the other constituents. Now if the B.t.u's are directly calculated on the volatile carbon and fixed carbon found, the only correction required is for the sulphur volatilized with the volatile carbon, which for all practical purposes will amount to one-half of the total sulphur found, and this correction can in most cases even be ignored.

The reporting of the volatile carbon (volatile matter, not water) and fixed carbon, enables the consumer to judge the

coal as to its being hard, soft or medium, and indicates its firing possibilities and its coking properties, none of which are indicated even from the determination of total volatile matter or direct B.t.u.

Given the grate surface and size, dimension of combustion chamber, and chimney and draft pressure, and size of coal, and amount of volatile carbon and fixed carbon one can quickly give an opinion as to whether the full efficiency is obtained and what the amount and kind of smoke will be.

In the discussion which followed, Dr. Sadtler and Dr. Hart spoke on some details of coal analysis. Dr. Hart called attention to the fact that when iron sulphide is present, both the sulphur and the iron yield heat, but the iron is often lost sight of. When the point was raised that besides the analysis of coal, the method of sampling was of greatest importance, Dr. Gudeman replied that the sample should be supplied to the chemist and that both the buyer and the seller should stand by the sample.

* * *

Steam Power Plant Economics.

Mr. Wm. M. Booth, of Syracuse, N. Y., presented a very long paper on "Steam Plant Economies from the Standpoint of the Chemical Engineer." The combustion of coal, the purification of water, and the control of flue gases are specifically chemical problems, while the designs of the boiler, the kind of fire box, and the physical parts of the plant are definite engineering problems. The chemist and the mechanical engineer here meet on common ground.

Mr. Booth first gave the detailed figures of the cost of a hp-year in a 24-hour plant of the best type, delivering 1000 hp to the generator. The figures were based on actual bids of manufacturers for the cost of apparatus with its erection in Syracuse. The figures do not include the electric generator.

In the first arrangement considered (steam engine) the fixed charges per hp-year (including interest, 5 per cent; depreciation, 10 per cent; taxes and insurance) amount to $7.20, the cost of operation (coal at $4 per ton, wages, etc.), $57.99; hence, total cost per hp-year, $65.19. In another arrangement with a gas-engine equipment the cost per hp-year comes out as $33.45.

Mr. Booth then gave figures of the various losses in steam-power plant, with special reference to Mr. Stott's paper read in 1906 before the American Institute of Electrical Engineers and took up the separate sources of loss with suggestions for improvement.

Water.—In selecting the location of a plant due regard should be given to water supply. The best modern practice is to locate where there are two available sources of supply, each entirely independent of the other. This is necessary not only in connection with the power plant, but also as a protection against fire.

The boiler water must usually be filtered to remove suspended mud, sand and detritus. If less than 10 grains of scale-forming ingredients are present, the softening process may be carried on in the boiler; if more (carrying particularly sulphates), a softening system should be provided. The heater does not remove all carbonates. If water is treated in the boiler, predetermined mixtures of alkaline hydrates and carbonates satisfy the conditions. Frequent blowing of sludge is very necessary with such treatment.

Coal.—While it may cost from 40 to 90 cents to raise a ton of steam coal to the surface of the mine, freight rates are such as to make coal cost in St. Louis $1 to $1.30 per ton, in Chicago $1.50 to $2, while Syracuse manufacturers pay $2.70, Watertown, N. Y., $3 and isolated cities in Massachusetts $4 to $5 per ton for very similar bituminous coal.

Coal should be purchased in the same way as iron ore, according to its value—so much per unit, with allowances for high ash and sulphur.

To ascertain grate economy, Mr. Booth made tests in four plants. The results were as follows: In the first 16 per cent combustible material in ash, 1.33 per cent coal not burned; in the second 31.5 per cent combustible material in ash, 4.6 per cent coal not burned; in the third 10 per cent combustibles in ash, 3.51 per cent coal not burned; in the fourth 36 per cent combustibles in ash, 5.6 per cent coal not burned. There is unquestionably an average fuel loss in ash that the power-plant owner might consider with profit.

Flue Gases.—Mr. Booth then discussed at some length the use of apparatus for testing flue gases. The general tendency in firing a boiler is to get a pronounced draft if possible and to drag an enormous quantity of air over the fire. This is air heated without useful results. The best means for determining the efficiency of combustion is by testing the CO_2 content of the flue gases by some CO_2 recorder like the Orsat.

Economizer.—To reduce the stack loss is the second serious problem for the power-plant specialist. Obviously the use of the heat in flue gases must result in large economy. Economizers attempt to recover much of the loss. When, however, water is heated in an economizer at the expense of draft, the very basis of boiler economy is endangered. A fair figure for the cost of a 1000-hp plant economizer would be $5 per horse-power. This equipment is relatively expensive and must result in a large saving if used. If the temperature of the flue gases is reduced from 500 deg. Fahr. to 250 deg. Fahr., saving from 8 per cent to 10 per cent of the coal is useful effort, an economizer ought to be an excellent investment.

Whether the stack will survive is a question. This time-honored and simple method of creating a draft is enormously expensive, approximating 20 per cent of all fuel burned in excellent plants and 50 per cent in poorly-managed plants. The chemist who is said to know no loss would expect to return the exhausted gases to the air at the same temperature as when taken. When this is done the boiler plant can be run much more economically. We are assured that the necessary draft for 1000-hp plant can be furnished mechanically at an expense of 1 per cent of the fuel burned and less if exhaust steam can be used to drive the fan.

Condenser.—"Are all familiar with the enormous loss resulting from the use of steam at low pressure? To condense 1 lb. of steam quickly requires from 14 lb. to 17 lb. of water which is heated without useful results. Thus it occurs that a 4000-hp steam turbine plant is supplied by a 4-in. feed-water pipe while the condensers are supplied with 12 mains. This water has to be heated and carried back to the fire bag with a total loss of the heat contained.

"Could the condenser loss be obviated and this energy be turned to mechanical advantage, the steam-power plant would take a new stand in the mechanical world."

In summing up Mr. Booth said that a highly organized electric plant is capable of delivering 10 per cent of the energy of coal as useful mechanical work. With the latest type of apparatus, including water-tube boilers, superheaters, and steam turbines, the efficiency has been raised to 15 per cent. Surely a remarkable gain over the 6 per cent or 8 per cent of a few years ago or the 3 per cent or 4 per cent of 50 years ago.

Four pounds of coal per hp-hour is good practice, but the steam turbine reduces this coal consumption nearly 50 per cent. With a gas engine and gas producer 1 hp-hour can be produced with 1¼ lb. of coal, producing an efficiency of about 22 per cent to 25 per cent. No steam or gas apparatus can compete with water power with an efficiency of from 87 per cent to 92 per cent of the total energy of the falling water.

Fixed charges are, however, heavy in large installations. A good boiler delivers 70 per cent of the heat of the coal, the average boiler not more than 50 per cent with the enormous condenser loss of the engine. The use of the boiler in chemical plants and wherever steam is required will probably never lessen, nor is this an inefficient apparatus for the purpose intended.

The use of the gas-engine exhaust for practical purposes, especially heating, will do much to bring this form of power into favor. The present cost of the large-unit gas engine and the uncertainty of its operation are opposed to its general use.

Undoubtedly the steam plant will continue for many years on a constantly increased scale as large installations result in the greatest economy.

That the plant may be made the most efficient, expert power-plant engineers must be employed. The plant must be *designed* by the most experienced and *operated* under the guidance of educated men—engineers, firemen and helpers.

The CO_2 recorder and recording pyrometer should be provided in every large plant, the Orsat apparatus should be used in all plants above 250 hp, the coal should be tested, the ash tested as well as the water from the boilers. Firemen should be paid in proportion to their results. Coal and ashes should be handled mechanically. If the plant is built fireproof, the insurance rate may be as low as 25 cents per $100; if not, it may rise to $7.

* * *

Scale and Corrosion of Boilers.

A paper on the chemical aspect of impurities which cause scale and corrosion of steam boilers was read by Mr. J. C. William Greth.

The author gave a systematic discussion of the impurities in boiler waters and their chemical nature, discussing in detail successively their action in forming scale and in producing corrosion. Scale and corrosion are closely connected. But in making general statements on this subject one has to be very cautious. The rate at which a boiler is operated is of great importance. Boilers need the best of water, hence treatment is generally necessary. But purification and softening of boiler water is a very delicate operation.

In view of the great amount of detailed information contained in the paper, it is not possible to give a satisfactory, concise abstract, and the reader must be referred to the full paper to be printed in the *Proceedings* of the Institute.

* * *

Examination of Flue Gases in Boiler Tests.

Dr. H. August Hunicke, consulting chemical engineer, of St Louis, Mo., presented a paper on the examination of flue gases in boiler tests.

If the composition of the fuel and the analysis of the resulting gases of combustion are given, it should be theoretically possible to state the entire history of the combustion process.

With a carbon fuel of simple composition (coke, anthracite coal, etc.) this is a simple chemical problem. But difficulties arise with complex bituminous coal, since this represents really a system of two fuels, one being gaseous hydrocarbons and the other the solid carbon residue, both portions participating at different times to a different extent in the process of combustion.

Dr. Hunicke has endeavored to solve the above problem on the basis of the published government report on the results obtained at the Fuel Testing Plant of the U. S. Geological Survey. But after careful study of the data of the government report he found that the variations of the firing process could not be followed by the individual analysis of the combustion gases made at intervals during each boiler test. However, while a detailed study of each boiler test was not possible, some interesting features were revealed by a study of the averages of the flue gas analysis.

Dr. Hunicke has calculated the results of the flue gas analyses for 78 boiler tests and plotted the results in a very interesting diagram.

The fundamental principle upon which a study of the flue gases is based is the constancy of the ratio of the sum of the volumes of oxygen and carbon dioxide to the volume of nitrogen. As the volume of the oxygen in the air is 21 per cent of the whole, the sum of the volumes of oxygen and carbon dioxide in a flue gas, omitting all interferences for the time being, should be 21 per cent. The term "oxygen equivalent" is used for the sum of volumes of oxygen, carbon dioxide and one-half of carbon monoxide calculated to its equivalent in oxygen as a means of comparison.

Dr. Hunicke's diagram gives curves for the flue gas composition (in terms of the oxygen equivalent) as it was found experimentally and as it would be theoretically for complete combustion. Three theoretical curves are given: one for complete combustion, without correction for ash, sulphur, etc., except CO; the second curve containing a correction for loss in ash and flue dust and CO; the third also containing a correction for sulphur, assuming that all sulphur burns to sulphur dioxide and is condensed with moisture before carbon dioxide is absorbed by sodium hydrate.

The chief object of Dr. Hunicke's paper is to compare the experimental and theoretical curves and to explain the discrepancies. While a number of the calculated values are very close to the experimental values, there are a number of values which deviate, in some cases very considerably, being either short of the calculated value or in excess of the latter.

All oxygen equivalents smaller than the calculated values seem to indicate that either more or less consumed gas had reached the flues and appears in the analysis as "nitrogen" or else that the samples analyzed were taken mostly during the period of gasification when a greater preponderance of hydrogen would reduce the oxygen equivalent. It is probable that the discrepancy is due to the second cause. It is disappointing to conclude that the number of flue gas analyses made during each boiler test were presumably too few and ill-chosen to permit the use of the results in the sense of representing true averages of the entire test.

The discrepancies were further studied by comparison with the O_2, CO_2 and CO analyses. For this purpose in the upper part of his chart, Dr. Hunicke shows side by side the averages of the carbonic oxide as found by analysis and the deviations of the oxygen equivalents. The diagram shows a parallelism which must be construed to mean that in the case of negative deviations combustion was incomplete, a deduction entirely in accord with the carbonic oxide determinations; while, on the other hand, the positive deviations would indicate that there has been an over-oxidation, a phenomenon not known in connection with the process under consideration.

The question then arises, how to account for oxygen equivalents deviating from the experimental results which are greater than those obtained by calculation? There is again the choice of two interpretations: Either the samples represented predominatingly the period of coke combustion; in other words, an insufficient number of samples were taken during the gasifying periods, or else the fuel analyses, and more particularly perhaps the hydrogen determinations, were in error. It would seem that both causes have been contributing to the discrepancies.

Dr. Hunicke urges that any complete set of data such as those in the government report must bear the searching test of a balance sheet, not only of the B.t.u's., but also the chemical masses which enter into the process. There seems certainly to be some unjustifiable element of uncertainty, due either to the analyses of the fuels or else those of the flue gases.

Greater care should doubtless be exercised in the chemical work of such extended series of boiler tests as those of the U. S. Survey, because it is impossible to foresee what information may at any time afterward be drawn from the data. However technical may be the work in its grosser features, elements which are measured should be measured with precision. It is to be hoped that in the future more powerful methods will be brought to bear on the problem in order to ensure not only accuracy of a high order, but also data which will most certainly yield information urgently needed as the competition between the different methods of fuel utilization becomes more keen.

Carbon dioxide recorders are doubtless invaluable as important elements in the recording of the performance of boiler plants, but we cannot for the present hope to gain information in greater detail than that most valuable instrument already records, unless technical research be directed to throw more light on the subject.

The American Institute of Chemical Engineers.

In the evening session of Monday, Dr. Charles P. Sadtler, consulting chemical engineer, of Philadelphia, presented in his presidential address "some thoughts on the organization of the American Institute of Chemical Engineers."

While Great Britain has five different national chemical societies and Germany three, the American Chemical Society in this country has been able to hold together in a more successful way all kinds and styles of chemists, the only notable exception being represented by the American Electrochemical Society.

"But while we heartily rejoice that the American Chemical Society includes in its membership such a general representation of chemists of all kinds and tastes, there is another phase of the question that must not be overlooked."

While scientific education should be on broad lines, there are many problems and interests that for their consideration require a degree of concentration and specialization. Most of the great industries involving chemical applications that have been built up and placed upon a basis that makes their present working lucrative, have achieved their success by the combined utilization of chemical knowledge, engineering skill and good judgment in the application of both.

These great industries, moreover, are not stationary in the conditions of their practice. The same chemical knowledge, engineering skill and good judgment must continue to be applied as advances are made in the sciences, or they will fall behind in the industrial competition.

There must, therefore, be a body of men supplied in increasing numbers who can take the technical charge of these industries, first as aides and ultimately as managers of the several works, qualified to continue the successful administration of the same and able to push them steadily to fuller development along safe and profitable lines.

The young graduate of the ordinary college or university course is not able to take up such work successfully, but it would be wrong to deprecate on that account scientific education and the value of college training. Yet we must realize that the applications of chemistry in the modern industrial arts, other than the metallurgical industries, are wider and more far-reaching than can be solved by the simple practice of the art of analytical chemistry, or application of the methods of chemical research learned in a university laboratory in connection with the writing of a thesis.

To be properly equipped for successful work in management and development of many industrial chemical processes, notably those utilizing organic materials, the chemist needs a more intimate acquaintance with the raw materials of the industry, whether fibers, cereals, gums, oils or resins, and the physical and chemical properties that are distinctive in each case, than is commonly obtainable in a college course of instruction.

Then, a knowledge of the laws of physical chemistry as affecting solution, reactions in the reversibility of the same under varying conditions, crystallization, and precipitation, has become recognized as of supreme importance, as the bearing and application of these laws to practical manufacturing problems has been pointed out.

Numerous applications of physical laws, mainly in connection with the application or utilization of heat, such as the question of steam raising, condensation and evaporation under normal and reduced pressure, or in connection with the development and utilization of electricity in factory practice, are also elements for the training of the technical chemist of to-day.

While, therefore, good analysts are and will continue to be in demand, there is also a present and prospective need for what, for want of a better title, we call "chemical engineers" to take responsible positions.

For these needs the American Institute of Chemical Engineers has been formed. It has been thought, however, that the new organization should not be merely a new chemical society, open to all who were interested in applied chemistry, but the membership, should be carefully restricted as to experience, age and occupation.

With reference to the name, it seemed to the majority of those connected with the organization of the new institute that the name "American Institute of Chemical Engineers" had certain distinct advantages and justification. The title of engineer is no longer limited and used to designate a narrow profession, but is rather a term of broad application used by those who, with proper preparation and training, are occupied with the study of the problems of a wide range of industries. Following the original division, now a very broad one, into civil and mechanical engineers, we have had the organization of mining engineers, electrical engineers, sanitary engineers, not to speak of hydraulic and marine engineers. Why should not those who devote themselves to the construction, development and management of chemical manufacturing works take for

—*Photo by Gutekunst.*

SAM. P. SADTLER,
PRESIDENT AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.

themselves the name of chemical engineers? By establishing an age limit and strict standards of qualifications for admission, the title is dignified and not made cheap.

It is probably within the experience of most chemical engineers that they have been asked to help both civil and mechanical engineers, who have been called upon for solutions of problems of public interest, but find themselves weak on the chemical questions involved. Why should the chemical engineers not strive to develop an organization from whose ranks experts could be taken when the occasion arises, thoroughly competent to advise upon all questions of the applications of chemistry for useful purposes, the abating of nuisances by chemical agencies, or the utilization of natural resources by means involving chemical processes.

To raise the professional standard among chemical engineers, to discourage and prohibit unprofessional conduct, is also a matter in which the individual has a personal interest.

The promotion of pleasant acquaintances and social professional intercourse among the members is an element of value at all meetings of societies, but it is more generally realized in organizations of limited or selected membership as in certain clubs than in the meetings of large organizations. The special field of industrial chemistry will bring together men of common interests and yet be broad enough to furnish the diversity and newness of presentation that will attract the members and give them something to repay their coming together. Both the social side and the professional side can be advantageously cultivated in such a gathering.

The papers presented at the meetings, together with the discussions, shall be printed in volumes of *Proceedings*. The institute shall also encourage the preparations of monographs or collective publications on selected topics of importance in industrial chemistry. There are numerous subjects of live inter-

est to all chemical technologists that could be taken up in this way. For instance, a collection and classifying of the most important publications from various journals on the contact-sulphuric acid process, beginning with the paper of Knietsch, presented to the German Chemical Society in 1901, and noting the most important patents and published discussions on the subject down to date, would make something that would be of value to all members and would also be worthy of publication in the name of the institute. The same could be said of the still newer topic of such universal interest to chemists, viz., the fixation of atmospheric nitrogen, or the older, but nevertheless, important object of the by-product oven and its possibilities.

Finally, it is hoped that studies on subjects of technical importance can be encouraged by the establishment of prizes or medals to be awarded statedly by the institute.

* * *

Pulverized Fuel for Industrial Furnaces.

Mr. RICHARD K. MEADE, of Nazareth, Pa., delivered a lecture, illustrated by many lantern slides, on the use of pulverized fuel for heating industrial furnaces.

In view of the fact that practically all the Portland cement at the present time manufactured in this country is burned with pulverized coal and that this fuel is also used for the nodulizing of fine iron ores, it seems strange that this method of heating furnaces has not been more generally used in industrial and metallurgical work. The chief advantage is that it is possible to burn powdered fuel with almost the exact amount of air necessary for combustion. This means the possibility of producing a higher temperature than with producer gas and solid coal; it also means a considerable saving

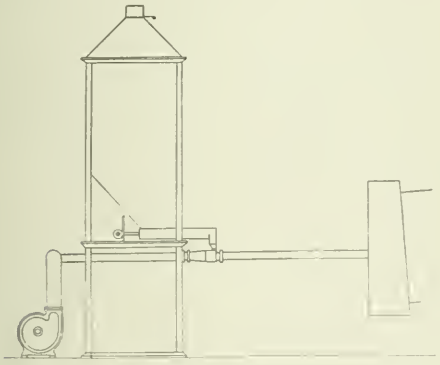


FIG. 1.—BURNING POWDERED COAL.

of coal, due to the smaller amount of excess air used. The carbon is completely burned, no carbon being left in the ash.

Furthermore, practically all the carbon is burned to carbon dioxide, avoiding losses due to incomplete combustion to carbon monoxide. Powdered coal has the advantage over gas firing in that the inherent losses of the gas producer are overcome. Mr. Meade estimates that the loss in gas producers may generally be considered as 30 per cent of the thermal value of the coal.

One objection to powdered coal is the danger of explosion But this is true only for powdered coal suspended in air. Powdered coal *en masse*—that is, when it is in a pile or in a bin—burns very slowly and with absolutely no explosive effects. The main point is to avoid the coal dust being stirred up and mixed with air.

The department of the plant in which the coal is ground should be always well ventilated so that no gas can accumulate. This can be accomplished by the use of a monitor running the full length of the roof and having slatted sides. Reinforced concrete offers a splendid material for the construction of fuel mill buildings, as the walls are straight and there are no projections to catch dust. The pulverizing department should be fireproof and located with at least an alley between it and the other parts of the mill. No naked lights should be allowed in this building.

When fires occur in grinding mills they may be best extinguished by the use of a tube of liquid sulphur dioxide kept for the purpose, or they may be smothered by steam. All this is by way of precaution only, however, as fires now rarely occur in fuel mills.

Coal-dust heating is well suited to obtaining high temperatures in open hearths. It is possible with this method of

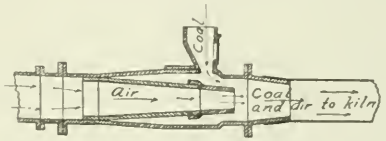


FIG. 2.—INJECTOR FOR LOW-PRESSURE AIR.

firing to get as long a flame as can be obtained with any other. The system was tried on a reverberatory furnace at Murray, Utah, and here it was said that it was possible when allowed to do so for the flame to heat and slag the stack brick.

With a rotary cement kiln 60 ft. long it is possible by closing all dampers to obtain a flame almost the entire length of the kiln. It is also possible by finely pulverizing the coal and using a damper to concentrate the flame within the first 20 ft. This makes the coal-dust flame one which may be very easily regulated so as to heat most strongly just that part of the charge which it is desired to have hottest.

The settling of the ash upon the charge is not considered by Mr. Meade to be serious, since the particles of ash, while occupying practically the same volume as the coal, have only from 10 to 20 per cent the weight of the latter and are therefore

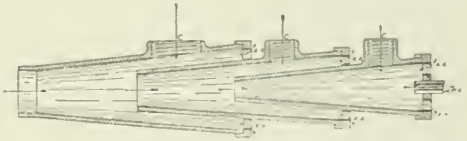


FIG. 3.—COMPOUND BURNER FOR HIGH-PRESSURE AIR

chiefly carried off by the strong draft which exists in most furnaces.

Where regenerative furnaces are used to heat the air for combustion, this ash, of course, may collect in the checkerwork of these. Where pulverized fuel is used for burning, therefore, the regenerators should be designed with large ash settling chambers and wide passages in the checkerwork. Damour and Queneau in their treatise on industrial furnaces give as their opinion that parallel counter-current regenerators are well adapted for use with furnaces heated by pulverized coal These regenerators avoid the use of valves, and it is possible with them to clean out the passages for the waste products by a jet of steam or compressed air or even with small and sharp water jets Just enough water should be injected to have instantaneous vaporization. If this is to be done care must be exercised to use in the regenerators such fire brick which will stand sudden cooling without "spalling." For such regenerators a design similar to a blast furnace hot stove would be advantageous, as these, being formed of a series of four solid walls, are easy to clean

In coal-dust firing the best results are obtained in a chamber in contact with highly heated material such as firebrick If the flame, on the other hand, comes in contact with a cold surface

mass as feeble flame the latter will reduce the temperature of the fuel and the air below the ignition point, resulting in incomplete combustion. For this reason heretofore coal-dust firing of boilers has not been used successfully, but there is no reason why, if the proper types of furnaces are used in connection with certain types of boiler, this system of burning pulverized coal in connection with boilers should not be successful. In the case of metallurgical furnaces, however, where the firebrick and charge are both at a high temperature, combustion is complete and very rapid.

Coals rich in volatile matter such as gas coal and lignite are best suited to pulverized firing.

As to the stack, with pulverized fuel all that is needed is sufficient draft to draw the products of combustion through the furnace with the desired velocity, which can usually be accomplished by the use of a short stack.

The method of preparing the coal for burning consists first in crushing it roughly between rolls or in a small pot crusher, and then drying and powdering it so fine that from 90 to 95 per cent of it will pass through a sieve having 100 meshes to a linear inch.

In order to get the greatest efficiency from the pulverizing machinery, it is necessary to dry the coal until it contains less than 1 per cent moisture. This is mostly done in inclined rotary-cylinder dryers.

Mr. Meade showed lantern slides of the Matcham coal dryer, made by the Fuller Engineering Co., of Allentown, and also described dryers of the Ruggles-Coles Engineering Co., the F. D. Cummer & Son Co., and the C. O. Bartlett & Snow Co.

Where the coal has been passed through a screen and consists of only pea and slack size, crushing is unnecessary. One of the best forms of pot crushers is what is known as a "coffee mill cracker."

When a set of rolls is placed before the dryer they are of the toothed form, such as are used to crush run of mine coal. These rolls are usually about 24 in. in diameter, with a 30-in. face.

When the rolls are placed after the dryer to prepare coal for a tube mill they should be plain faced or only slightly corrugated. The toothed rolls usually reduce run of mine coal to 2-in. lumps and under, and the plain-face rolls will crush to lumps ranging from ½ in. down.

When coal is first passed through a screen and consists of only pea and slack size, rolls and pot crushers are unnecessary. After being reduced to 1-in. lumps and under, the coal may be ground to the necessary fineness directly by either Fuller-Lehigh mills, or Griffin mills, or tube mills, preceded by some form of preparatory mill, such as a Williams mill, a Steadman cage disintegrator or a set of smooth-faced rolls. Several of these mills were described and shown in lantern slides.

The method for burning powdered coal is shown in Fig. 1. It consists of an injector, through which the air is forced by a pressure blower at a pressure of about 0.6 lb. The coal is conveyed out of a bin by a screw conveyor, falls into the injector, is sucked in and mingles with the air as it passes through the pipe to the furnace.

The injector is usually of cast iron, the pipe leading to the furnace is of galvanized iron and terminates in a nozzle of wrought-iron pipe, which projects for a foot or more through the hood into the furnace. The screw conveyor leading from the bin is run usually by a line shaft attached to the fan or the motor driving fans. The connection with the shaft is made either by some form of speed controller, or else by a stepped pulley, so the coal feed can be regulated.

The air blown in is usually constant and may be varied from only a fraction of that needed for combustion to the complete amount. In some cases air from the compressors or high-pressure air is used, and in others a combination of the two is sought. The main object in any event is usually to carry the coal into the furnace and to get a good mixture of coal and air, the rest of the air being drawn in by the draft

Fig. 2 shows the construction of an injector for use with low-pressure air The construction of the burner is evident from the drawing.

Fig. 3 shows a compound burner intended for use with high-pressure air. The coal drops down at the three points, *C*, *C* and *C*, the air from the compressor enters at *H P A*, and a certain amount of atmospheric air is sucked in at the openings, *A A*. As to the relative merits of the two, the low-pressure air is much the simpler of the two where a compressor would have to be installed.

With the low-pressure system it has been found best to blow into the kiln at least 20 per cent of the air necessary for combustion with the coal. With the high-pressure air, however, only about 5 per cent of the necessary air is obtained from the compressor. This air is usually delivered to the burner at about 80 lb. pressure.

Now, to burn 100 tons of gas slack per day, about 4000 cu. ft. of low-pressure air, or 1000 cu. ft. of high-pressure air, per minute will be needed. The theoretical horsepower required to supply 4000 cu. ft. of air at 1 oz. pressure amounts to 1.4 hp. To compress 1000 cu. ft. of air to 80 lb. pressure, 137 hp will be theoretically required. Hence there is considerable saving in the use of low-pressure air.

Mr. C. A. Matcham has recently invented a system of burning powdered fuel, which makes use of the natural draft of the furnace to suck the coal in. About 0.4 to 0.6 in. of water draft is needed for this system.

Finally, Mr. Meade gave some estimates of the cost of preparing pulverized coal and of the cost of operation of such a plant.

* * *

Pyrometers.

Dr. Edwin F. Northrup, of Philadelphia, partner of the firm of Leeds & Northrup, presented a paper on modern resistance pyrometry.

All temperature scales are ultimately referred back to the gas thermometer scale and comparison is made indirectly with the aid of the melting points of a series of pure metals (gold 1060° ± 1° C., A. L. Day and J. K. Clement; platinum 1753° C., Bureau of Standards). The constant-volume nitrogen gas thermometer is reliable in the region from 300° C. to 1150° C. to ½° C.

A distinction must be made between the sensitiveness and the accuracy of a pyrometer. A pyrometer may be exceedingly sensitive to note changes in temperature and constant in its performance, and yet give no certain indications of actual temperatures. A pyrometer of this character may be useful in enabling one to repeat temperatures, as shown on an arbitrary scale, which have been found by trial to be most suited to a given process.

These relative measurements of temperature have, however, two important disadvantages and limitations over absolute measurements. First, many manufacturing plants have several branches in different sections of the country, each branch making the same product by like processes. If at one branch it is found by trial that the best results are obtained when a particular pyrometer gives certain indications on an arbitrary scale, these results cannot be interpreted so as to be communicated to the other branches of the plant. Thus, each branch must learn by its own experimenting.

Second, if the particular instrument is broken or goes out of calibration, the whole process of experimentation must be repeated with a new instrument or scale having a different constant. This seemingly obvious consideration shows the great desirability of having pyrometers read accurately in actual degrees Centigrade or Fahrenheit and not merely scale divisions which are relatively correct, but not capable of being interpreted in actual temperature degrees.

Foremen often believe that they have trained their eyes quite accurately to judge temperatures with sufficient exactness. But

the condition of the light, retinal fatigue and imperfect memory all influence estimates of this kind to such an extent as to make them practically valueless.

Foremen and workingmen are often opposed to the use of pyrometers because they believe them to be "too complicated, too delicate, and unreliable." The question arises where to find the source of unreliability. Any electric pyrometer (whether of the resistance or the thermoelectric type) contains the "bulbs" located at the points the temperature of which is desired; the indicator with which the temperature of the bulbs is read, and the system of wires which join the bulbs with the indicator. The bulbs, so to speak, are the finger tips that feel the temperatures, and the wires are the nerves that put these into communication with the interpreting indicator, the brain. Defects in the bulbs, or in the indicator, give false temperatures, and defects, such as opens, crosses, grounds and leaks, on the connecting wires stop or falsify the communication between bulbs and indicator.

Of these parts, the indicator and the resistance thermometer bulb have been worked out by the manufacturer until they are no longer fragile, inconstant or unreliable. But, however well these may be constructed, electrical resistance pyrometers will continue to be unreliable unless the wiring system where they are installed is properly done and properly cared for.

If a mechanical engineer wishes to transmit 10 hp across a factory, he puts up in a substantial manner a line of shafting and it stays in order. An electrical engineer could carry the same power across the factory with a single wire, the diameter of a pin, laid on the floor.

He can thus with slight effort get his results at once and the temptation is great to put up flimsy, uncertain wiring, but such transmissions are short-lived, and it is then, indeed, invidious to say, as is often done, that electrical installations cannot be relied upon like mechanical installations. If the 10 hp were carried in a lead-incased cable, as substantially supported as the shafting, and as carefully connected to generator and motor at its ends as is the shafting, the electrical transmission would remain in operation when a line of shafting and belts had rusted and rotted into uselessness.

The conclusion of this is that electrical resistance pyrometers are not only capable of being very accurate within 2 to 5 deg. at 1200° C., but can be made entirely reliable, if they are installed with like care that is put upon important mechanical installations. As the methods worked out for such proper installation is the busines of experts in pyrometer work, no plant should be installed without following wiring diagrams and full instructions given by such experts.

No fixed design of pyrometer is suitable for all different manufacturing purposes. The resistance thermometer has its limitation in the measurement of high temperatures at a temperature around 1200° C. Above this temperature, the platinum wire used slowly volatilizes, producing a slow but continuous increase in the resistance at a given temperature of the resistance wire. Below this temperature, down to that of liquid air, the resistance thermometer is, in the author's judgment, more accurate, more reliable and capable of utilizing more energy than the thermocouple. Above 1200° C. and below 1600° C. the platinum, platinum plus 10 per cent rhodium thermocouple will take its place. Above 1600° C. radiation or optical pyrometers must be used.

As already stated, for temperatures below 1200° C., some form of the resistance pyrometer is generally most suitable But these vary in many respects, the most important one being the kind of protecting case which must be used so that the pyrometer will be accurate and quickly assume its temperature, and yet be so protected as not to be easily injured or destroyed by rough usage or handling. Thus, a pyrometer merely encased in a porcelain tube might serve well if permanently inserted in flue gas, but be useless for taking the temperature of molten lead in kettles. Prospective purchasers cannot be urged too strongly, for their own interest, to furnish sufficient information to the manufacturer of pyrometers to enable him to give adequate advice on the best solution of the engineering problem to be met.

The charge of unreliability might have been made in the past with greater justification against the recording devices used with recording pyrometers than against the pyrometers. But in the latest design reliability of the recorder has also been obtained.

In the concluding part of his paper, Dr. Northrup described the many fields of applicability of pyrometers. One particularly interesting application was made in connection with the recent tunnel building under harbors and rivers by the Pennsylvania Railroad. At the foot of East Thirty-fifth Street, New York, a tunnel of small diameter was run underneath a part of the East River. By means of pipes laid in this tunnel, brine at about —35° C. was circulated for months in the tunnel. Its low temperature abstracted the heat from the walls of the small tunnel, freezing in cylindrical zones the silty soil. The frozen material thus formed a hard, self-supporting mass which would permit the enlargement of the small pilot tunnel to its full required diameter. The progress of the freezing was observed by hundreds of resistance thermometers located in the soil at varying distances from the axis of the tunnel. The difference in temperatures of the entering and leaving brine—a difference of less than 4° C.—was registered to an accuracy of 0.01° C. by means of resistance thermometers and their registrations were photographically recorded, without interruption for months. The measurements of temperature by means of electrical resistance thermometers in this experiment were entirely successful and accordant.

It is in glass-annealing ovens and leers that the resistance pyrometer finds itself in most congenial temperatures, and renders a most valuable record. If the glass in the ovens gets too hot it melts in the ovens. If it gets too cool, it cracks in customer's hands and complaints and replacements or loss of business occur. In a typical installation in a large glass works, several pyrometers are permanently installed in the ovens and leers. A deflection type indicator, which by turning a single handle is switched upon any pyrometer, tells the foreman how his heat is running. A dial indicator in the superintendent's office enables the temperatures of the same pyrometers to be read there at the same time, and an autographic recorder may be switched upon any oven and give the history of its temperature run in the form of a perfect ink record. This is drawn upon a long sheet of cross-section paper, 10 in. wide, which may be cut up into lengths of 6 ft., each representing runs of 24 hours, and filed for future reference.

In closing, Dr. Northrup said that the theory of resistance pyrometers is fully developed and shows the possibility of rigidly accurate results being obtained; the engineering details have been developed so all temperatures from that of liquid air to 1200° C. may be both accurately indicated and recorded, and lastly, these results can be actually obtained in practice and, indeed, are now obtained, with installations which are reliable, in defiance of the prevalent opinion to the contrary But to make the last statement true, intelligence of a good order must be used all along the line from the manufacturing and calibrating of the instrument to their adequate and proper installation. If intelligence is used thus far, very ordinary persons can use the instruments and understand their indications. Though, even here, in the case of large installations of many pyrometers, it is of doubtful commercial economy not to employ, with suitable recompense, trained persons who are fully capable of using apparatus which is so difficult to render entirely "fool-proof."

* * *

Liquid Ammonia.

Dr. F. W. FREERICKS, of St. Louis, Mo., presented a paper on apparatus for testing liquefied ammonia gas.

A review was given of the devices now in use in this country and abroad, and it was pointed out that a source of error inherent in some of them was the moisture contained in the atmosphere, which could not be excluded from the sample The new apparatus excludes this error entirely and its accuracy was

...ssrs. ... by repeating the experiments of Lange and Heff... *Industrie*, 1898, page 2), with liquefied ammonia gas of the greatest prity, and also with mixtures of this ammonia with known quantities of benzole, pyridine, alcohol and water.

The liquefied ammonia gas used in these tests had been made from sulphate of ammonium previously purified from all volatile carbon compounds. For this reason it was certain that no carbon compounds like benzole, pyridine, alcohol, etc., could be present, and the limit of water was ascertained (by treatment with metallic sodium and measuring the hydrogen evolved) to be less than 0.002 per cent.

The average of five analyses made in the new apparatus of this ammonia showed it upon evaporation to leave a residue of not more than 0.00175 per cent, consisting principally of water, iron oxide and lubricating oil, while Lange and Heffter, using Urban's method, have worked with liquefied ammonia gas leaving upon evaporation 0.2 per cent of a non-volatile residue.

Evaporation test of pure liquefied ammonia gas containing known quantities of benzole, pyridine, ethyl alcohol or water:

Substances present.	Liquid NH_3. Grams.	Addition. Grams.	Addition evaporated. Per cent. by Urban.	Per cent. by Frerichs.
Benzole and pyridine	99.0	1.0	..	15
Benzole	98.5	1.5	41	59
Pyridine	99.0	1.0	33	24
Ethyl alcohol	99.0	1.0	20	17
Water	98.0	1.1	17	11

Used ammonia leaving upon evaporation. Per cent.	
0.2	None

The limit of accuracy of testing with the new apparatus has been ascertained as follows:

For water to .....0.002 per cent.
For alcohol to .....0.006 " "
For pyridine to .....0.009 " "
For benzol to .....0.110 " "

The new process of Dr. Frerichs (United States patent 905,415, Dec. 1, 1908) for making pure liquid ammonia is about to be tried on a large scale. Its essential features are as follows: Commercial sulphate of ammonium is heated in a still to about 200° C.—a temperature sufficiently high to volatilize the carbon compounds in the salt and to convert the nitrogenous-organic compounds into sulphate of ammonium by reacting with the sulphuric acid of the ammonium salt. No considerable quantities of ammonia gas are thereby liberated from the salt. To facilitate the process of purification, an air blast may be introduced in the still. After this purification process is over, the temperature is raised to 350°, to get the reaction

$$(NH_4)_2 SO_4 = NH_4 HSO_4 + NH_3.$$

If the temperature is further raised to 400° C., the reaction is quickened. No ammonia is destroyed, but the acid sulphate of ammonium is decomposed into pyrosulphate of ammonium and water:

$$2\,NH_4 HSO_4 = (NH_4)_2 S_2O + H_2O.$$

The resulting pure ammonia gas is then worked into the desired products, while the acid sulphate of ammonium and pyrosulphate of ammonium resulting from the operation are dissolved in water, and the resulting solution of acid sulphate of ammonium is utilized for absorbing volatile ammonium compounds and impure ammonia gas coming from crude ammoniacal liquors during the initial distillation thereof or otherwise obtained. This completes the circle of operation, the sulphate of ammonia thus obtained being treated as before.

* * *

Tuesday Evening Session.

In the evening session Dr. J. Herbert Brewster presented a very interesting paper on "the sanitary condition of the southern end of Lake Michigan." The paper was illustrated by lantern slides, and gave a review of an extended investigation, revealing a horrible state of affairs due to the contamination of the water by a glucose factory, several sewers, etc. The currents of the different contaminated streams were carefully traced. The author also discussed possible remedies.

Of equal interest, though of an entirely different nature, was the paper by Dr. William M. Grosvenor, consulting chemical engineer, of New York City, on "dryer calculations and dryer designs." The paper went right to the root of the matter, giving the fundamental thermodynamics of the drying process. The paper was illustrated by various elaborate diagrams. We hope to publish this paper in full in a later issue.

Mr. Thorn Smith's interesting contact-process paper was read, in absence of the author, by the secretary. It gave an account of some experiments with the ferric iron contact method of making sulphuric acid from smelter fumes. We reserve an abstract for a later issue.

The other papers were read by title. We quote their titles from the printed program:

"Testing and Performance of Steam Generating Apparatus," A. Bement.

"Producer-Gas Installations," Ernest Schmatolla.

"Work of the United States Government Fuel Testing Plant at Denver, Col.," A. W. Belden.

"Chemical Specifications for Sulphite Pulp," J. A. De Cew.

"Cement Manufacturing Methods," J. G. Dean.

After the usual vote of thanks the meeting adjourned.

The secretary of the American Institute of Chemical Engineers is Dr. John C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

Transport of Ferrosilicon.

The English press, technical and otherwise, is again full of remarks on the dangers of ferrosilicon. The death of five men in the emigrants' quarters of the steamship *Ashton* occurred in a peculiar way, as follows: Five Russian emigrants left Antwerp by the *Ashton* on Dec. 12, and the same evening were seen to be suffering from what was naturally assumed to be seasickness. The next morning four of the five were discovered dead and the other one was in a dying condition.

The emigrants were berthed between decks and directly above the forehold, which contained, among other things, nine tons of ferrosilicon in barrels. A hatchway gave communication between the places. When the master of the vessel went down he detected no unusual smell, but was very ill after the visit. He sent for the port authorities on arrival in the harbor, and the sanitary officer noticed a smell which he did not recognize at the time, but afterwards knew to be "that of ferrosilicon." The forehold, where the stuff was stored, was perfectly dry, and the ship was passed A1 at Lloyd's three months ago.

Evidence was given by Mr. J. A. Foster, analytical chemist, of Hull, to the effect that the ferrosilicon contained besides iron and silicon also carbon, phosphorus and arsenic. Five gases were given off, namely: arseniuretted hydrogen, phosphoretted hydrogen, acetylene, pure hydrogen and sulphuretted hydrogen. Pure hydrogen, the witness said, was of an asphyxiating nature, and the other gases were very poisonous, arseniuretted hydrogen being most intensely so, a single bubble having been known to cause death. Phosphoretted hydrogen was nearly as deadly. In less than 24 hours the nine tons of ferrosilicon, if dry, would give off 110 cu. ft. of extremely deadly gas; and if the stuff were moist, thrice that amount would be evolved. The gas given off by the ferrosilicon in the hold would have killed a hundred people. The early symptoms were liable to be mistaken for those of cholera or ptomaine poisoning. The gas decomposed the blood. Ferrosilicon was most treacherous; if sealed in drums it was liable to explode, and if cased in barrels it gave off the poisonous gases mentioned.

The Swedish government recommends that in passenger vessels, ferrosilicon, if carried, should be on the open deck and away from cabins, etc. It does not advise packing it in hermetically-sealed drums for fear of explosion. By railway it should travel in open trucks, covered with water-tight tarpaulin.

The Methods of the United States Steel Corporation for the Commercial Sampling and Analysis of Iron Ores.

(Copyright, 1908, by J. M. Camp, Chairman Chemists' Committee.)

Iron Ore Sampling in General.

Owing to the varying conditions under which iron ores must be sampled, both by the producer and the consumer, variations from any uniform procedure of sampling are necessitated. The elements of time, size of shipment, kind of ore and other considerations are determining factors in the details of procuring the sample. Hence it is the purpose to render the following methods general in their scope, promulgating those ideas applicable in the broader sense to ore sampling, without attempting to prescribe for every varying and unforeseen contingencies in the details.

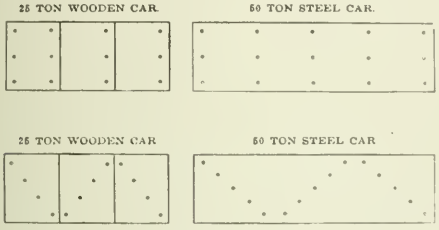


FIG. 1 (ABOVE).—PARALLEL SYSTEM.
FIG. 2 (BELOW).—ZIGZAG SYSTEM.

Car Sampling at Producer's End.

All samples must be taken uniformly over the surface of the cars after being loaded by taking a minimum of 12 places for wooden, and 15 places for steel cars, by either the parallel or the zigzag system. The above diagrams illustrate these two systems and show the minimum number of points where samples are to be taken.

When lumps of ore are encountered at the designated points where samples are to be taken, small portions of each lump must be chipped off, about equal in size to the first joint of the thumb. When rock occurs it must also be sampled as ore, that is, a proportionate amount of the rock or off-grade material is to be taken, not equal in amount to the regular sample for the area covered by that point, unless the entire area is such off-grade material. Then the same amount of adjacent material must be taken, or ore or rock, equal in amount to the portion taken at each regular point. This also applies to field boulders, unless thrown from cars.

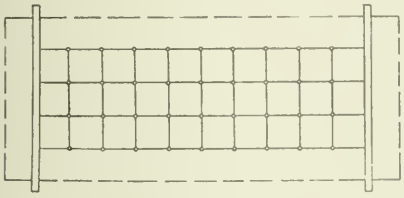


FIG. 3.—ROPE-NET SYSTEM.

The samples are taken with a garden trowel. Each 10 cars, either steel or wooden, must be combined, as a rule, into one sample; but less than 10 cars may be grouped. The weight of the sample must not run under 15 lb. for 10 wooden, and 20 lb. for 10 steel cars.

Whenever very lumpy ore is to be sampled in the cars, the rope net system is used, as shown above, which gives about 32 places on each car, the knots being 18 in. apart. In using the net system, if a lump of ore or rock comes directly under a knot, a piece should be taken about the size of the first joint of the thumb. If fine ore occurs under a knot, an equal amount is taken with the trowel. The rope net system is used at the Marquette Range on the hard, lump ore; also at the Soudan Mine, Vermilion Range.

A moisture sample must be taken for each train load from all open pit mines; a train consists of 40 to 45 of the 50-ton steel cars, or 60 to 68 of the 25-ton wooden cars. A moisture sample must also be taken for all the cars loaded at a shaft or stock-pile during each 10-hour shift. Samples must be taken from three places on top of each car, as shown by the following diagram.

FIG. 4.—MOISTURE SAMPLING.

Care should be taken to secure the sample from well underneath the surface as soon as practicable after loading, maintaining the true proportion of lump and fine ore. The sample as taken must be immediately placed in a can with a tightly fitting lid, and brought to the crusher house. It is optional to take a moisture sample from the regular sample, provided it has been taken from well underneath the surface.

Cargo Sampling at Consumer's End.

Cargo ores present the most serious obstacles to a uniform method of sampling. The boats vary in size from 3000 to 12,000 tons, with one or two decks, and in the number of hatches from 6 to 36, with widths varying from 12 ft. to 24 ft. The grabs at the different unloading points vary in number, kind and size, and the rapidity of their operation. The ores vary from the very fine to the all-lump, from the so-called mixed ores, such as the groups to the mixed cargoes, consisting of different ores in the same boat, and with different ways of loading the boats.

Grab Sampling.—An excellent method of cargo sampling where the entire cargo will be represented, and particularly adaptable for fine ores, is called grab sampling. A sampler with a small scoop attached to a handle of suitable length and holding a definite amount of ore, a quarter, a half or a whole pound, takes a scoopful from each grab as it rises above the deck. The disadvantage of this system is its increased cost due to the extra number of samples, one being required for each grab during the entire time of unloading.

FIG. 5.—CONE SAMPLING

The general plan for the sampling of all cargoes is to first sample the tops of the piles, before the grabs have started to unload; this is called sampling of the cones. After the grab has removed from the hatch all the ore within reach, the exposed faces standing on each side are sampled, this method is known as face sampling. Or when the latter practice is impracticable owing to the operation of the grabs, then the method of rounds is followed.

In sampling, a small shovel or garden trowel is used, the total length of which, including the handle, is 12 in., and it also constitutes a measure. It is the aim to take equal sized samples from each of the points selected. When lump ore or rock

is commenced at the point determined by the measure, a portion is broken off equal to the amount regularly taken.

In the sampling of the cones, at a point midway between the side and the center of the boat, directly under the edge of the hatch the first sample is taken and sampling continued one shovel length apart up the surface of the cone, over its apex and down the opposite surface to a corresponding point under the other edge of the hatch. This line is crossed from corresponding opposite points under the hatch, as shown in the following sketch. Not more than one-tenth of the total sample is to be taken in the sampling of the cones.

Face Sampling.—After a grab has removed from a hatch all the ore within reach and has moved to another hatch, the sampler shall measure two shovel lengths from the side of the boat and start up the exposed face of the ore, taking samples one shovel length apart all the way to the top, using a ladder if necessary. The next vertical line is measured four shovel

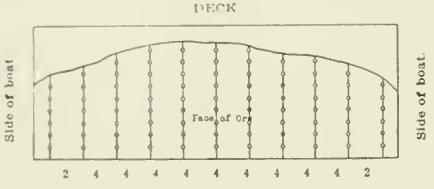


FIG. 6.—FACE SAMPLING.

lengths from the first and the samples taken each shovel length apart on this line as before, and so on for each succeeding line across the boat. This is repeated on the opposite ore face, and the entire procedure continued until the ore faces of all the hatches are sampled that the character of the boat and the operation of the grabs will permit. When a bulkhead occurs only the face opposite to it is to be sampled.

Round Sampling.—When the operation of the grabs makes sampling by the face method impracticable, or with boats having 24 ft. hatch centers, and decks furnishing protection to the samplers, then sampling shall be done while the ore is being removed by the grabs. When 5 ft. or 6 ft. of the face of the ore have been exposed, the sampler shall enter the hatch and measuring two shovel lengths from the side of the boat or edge of the face, take successive samples up the face one shovel length apart. The next vertical line is measured four shovel lengths from the first, and samples are taken all the way to the top as before, and so on across the entire face of the ore. This procedure is repeated on the opposite face, one-third of the total weight of the sample to be taken in the first round. When all the ore within reach of the grab is removed, the second round is taken, using the measurements as above, and the remaining two-thirds of the sample are secured.

Part of the regular sample is to be taken for the moisture sample, and for the fineness sample when such is desired.

Car Sampling at Consumer's End.

When the ore is received in cars the greatest possible number are represented in the samples, and not less than 10 equal-sized samples are taken from each car. When cars are loaded with fine ore, with the piles in opposite ends, at least five samples are taken from each pile, the first one at the apex of the pile and the other four at points symmetrically arranged around the apex of the pile, two-thirds of the distance from the apex to the bottom of the pile or sides of the car. With cars loaded in two pockets the system is the same, except that the center of the pile lengthwise of the car is the first point, the other four being symmetrically arranged around this point.

When the samples are located in a car, each of them is supposed to represent a definite area, equal to one-tenth of the ore surface of the car. If the car contains all fine ore, then 10 equal-sized samples are taken, one from each of the points. If the car contains a mixture of fine and lump ore, with varying amounts of each in the areas included in the different divisions, then each area is judged separately and sampled accordingly. The fine and lump ore are taken each in its proper proportion, the former with the trowel, the latter being shipped or selected small pieces being taken, each about the size of the first joint of the thumb. The combined sample of fine, chipped and selected pieces from each area equals the amount taken were it all fine ore. If the contents of the car are all lump ore, the proper sized pieces are chipped from four or five lumps in each of the 10 areas, making 40 or 50 pieces from each car, the total amount of chipped pieces from each of the areas equalling the amount that would be taken were it all fine ore. All samples of fine ore are taken from well underneath the surface to obtain the ore in its natural state.

A proportionate amount of the main sample is retained in a tightly closed can for the moisture determination.

Preparation of Samples in General.

In the preparation of the sample for analysis, the ideal practice is to crush and quarter alternately until the desired quantity with the requisite degree of fineness is attained. A more expeditious and equally efficient method, is to crush the entire sample to the desired degree of comminution, then reduce the quantity by successive quartering as before, until the desired amount remains. It should ever be our purpose to approach as closely as possible to either of these two methods in the preparation of all samples for analysis.

Preparation of Sample at Producer's End.

Samples before being quartered are brought into the crusher house, where they are dried, if necessary, at 100° C., until the ore can be well mixed. Care must be taken to prevent overheating when other than low-pressure steam is used for the purpose, especially with ores containing a large quantity of limonite. When sufficiently dry the larger lumps are crushed, if necessary, so that the entire sample will pass through a ½-in. mesh sieve; a finer sieve may be used if desired. The sample is thoroughly mixed on an iron-top table, then spread out evenly about three-fourths of an inch in depth and alternately quartered and mixed until one-fourth of the original sample remains. It is now crushed until fine enough to pass a ¼-in. mesh sieve, then mixed and quartered as before until about 2 lb. remain. It is again crushed until fine enough to pass a 20-mesh sieve, and spread out evenly about ⅜ in. in depth. About 3 oz. of this is taken from all over the pile, with a small spatula, dried in a small pan at 100° C. and crushed on a chrome-steel plate, until it will all pass through a 100-mesh sieve. After being thoroughly mixed this is transferred to a bottle, and constitutes the sample for analysis.

The following method for the preparation of the sample is optional: All the ore is passed through a ½-in. sieve, thoroughly mixed on a suitable cloth and quartered in the usual way, diagonally opposite portions being rejected until about 5 lb. remain. The sample is again crushed, if need be, to pass a ¼-in. mesh sieve, and mixed and quartered as before until 1½ to 2 lb. remain. After being dried at 100° C. for 20 to 30 minutes, it is crushed to a fineness of 20 mesh, mixed and quartered until about 3 oz. remain, and the entire sample is crushed on a chrome-steel plate and passed through a 100-mesh sieve. This sample is spread out in a shallow pan, dried at 100° C. for 30 minutes, again mixed and transferred to a 3-oz. bottle or can for the analysis.

Preparation of Sample at Consumer's End.

The aggregate sample is dried at 100° C. and crushed before any quartering whatsoever, so that the entire mass will pass through a ½-in. mesh sieve. This is reduced by successive quartering and crushing until its weight is from 4 to 8 oz., and it will then all pass through an ⅛-in. mesh sieve. Or the entire sample is crushed so it will pass through an ⅛-in. mesh sieve,

and then quartered as before until from 4 to 8 oz. remain. And this final quantity is then further crushed with a chrome-steel bucking board and muller and all passed through a 100 mesh sieve. A sufficient amount of this powder for all the needs of the analyst is placed in a small air-tight container, dried for one hour at 100° C. and when cool it constitutes the sample for analysis. A separate, larger portion of the same sample is retained for further needs.

Iron.

BY THE BICHROMATE OR PERMANGANATE METHODS.

One or more portions of ½ to 1 gram of the ore are placed in a beaker and 5 to 10 cc of the solution of stannous chloride and 5 to 25 cc of strong hydrochloric acid are added. This variation in the amount of acid is due, aside from the variations in the weight of the sample and the varying solubilities of the ores, to the fact that while in the permanganate method the minimum amount of free acid should be present, with the bichromate method an excess of acid is essential. The beaker is covered with a watch glass and heated gently on the steam bath, or hot plate, until all iron is dissolved, and if the permanganate method is to be used, the volume of the solution is reduced by evaporation so as not to exceed 10 cc. While still hot the stannous chloride solution is added from a burette, drop by drop until the color due to the ferric chloride just disappears, and then one drop in excess. The solution is diluted to about 350 cc with cold water, 5 cc of mercuric chloride solution are added and the solution is thoroughly stirred. From this point the bichromate or permanganate titrations are optional. In the former case, the potassium bichromate solution is added from a burette until a drop of the solution being titrated, added to a drop of the potassium ferricyanide solution on a paraffined plate shows no ferrous iron. In the latter case, 10 cc of the titrating solution are added for a ½-gram sample, and 20 cc for 1 gram. The solution is stirred and titrated with the potassium permanganate. In either case, the number of cc used multiplied by the respective factor gives the percentage of iron.

If the residue is suspected of containing iron it is filtered off, ignited and fused; the fusion is dissolved in water, acidified with hydrochloric acid, and the solution reduced and titrated as above; or the solution before being acidified is filtered, the ferric oxide on the filter is dissolved in hydrochloric acid and added to the main solution or titrated separately.

Solutions for Iron Titrations.

The stannous chloride solution is made by dissolving 250 grams of the salt in 500 cc of strong hydrochloric acid, and diluting to 1000 cc.

The mercuric chloride solution is saturated in the cold.

The potassium ferricyanide solution is made fresh each day by dissolving in the proportion of 0.100 gram of the salt in 100 cc of water.

The potassium bichromate solution is made by dissolving the salt in the proportion of about 8.9 grams to 1 liter of water, and standardizing with an iron ore, iron wire or steel of known iron content. One cc equals approximately 1 per cent iron with a 1-gram sample taken for analysis.

The titrating solution is made up in the following proportion to the liter: 90 grams of manganous sulphate are dissolved in 650 cc of water, 175 cc of strong sulphuric acid are added, then 175 cc of phosphoric acid of 1.75 specific gravity, and the solution is filtered if necessary.

The permanganate solution is made by dissolving the salt in the proportion of about 5.7 grams to 1 liter of water and standardizing in the same manner as the bichromate solution. One cc equals approximately 1 per cent iron with a 1-gram sample taken for analysis.

Silica.

USING 1 GRAM WITH HYDROFLUORIC EVAPORATION.

One gram of the sample is transferred to a porcelain dish, or a beaker, with watch-glass cover, and 20 cc of strong hydrochloric acid are added. A gentle heat is applied until the ore is dissolved and the solution is then evaporated to dryness, unless it has been conclusively shown to be unnecessary. (See footnote.*) To the residue, which should not be heated above 120° C., 15 cc of dilute hydrochloric acid (1 part acid to 1 part water) are added, heat is applied until the salts are dissolved and the solution is diluted with hot water. The precipitate is filtered off, washed, ignited at the highest temperature of the blast lamp or muffle furnace for at least five minutes, cooled and weighed. To the residue in the crucible one or two drops of strong sulphuric and 5 cc of hydrofluoric acids are added, and the solution is evaporated to the expulsion of sulphuric acid. The residue is ignited as before and again weighed; the difference between the two weights is silica.

Silica.

USING 1 TO 5 GRAMS WHEN ALL OR PART OF THE FILTRATE IS USED FOR THE PHOSPHORUS OF OTHER DETERMINATIONS.

One to 5 grams of the sample are transferred to a dish (beaker optional) with a watch-glass cover, 20 to 50 cc of strong hydrochloric acid are added, and a gentle heat is applied, without boiling, for about one-half hour. The solution is diluted with an equal volume of water, filtered into another dish of the same size, and the visible iron stain is washed out of the filter paper. This solution, containing the bulk of the iron, is allowed to go to dryness on the steam bath. The residue is ignited in a platinum crucible, and then fused with about six times its weight of sodium carbonate. The fusion may be leached out of the crucible, but it is found more expeditious to let it cool around the end of a platinum rod, and on again heating the crucible the entire mass adhering to the rod is removed. It is then dissolved in the original filtrate, or placed while still hot in the covered dish, in which the original solution was made and to which about 25 cc of hot water have previously been added. The small amount remaining in the crucible is dissolved in hot water, and finally in hot dilute hydrochloric acid (1 part acid to 1 part water), and added to the dish containing the fusion, which by this time has been disintegrated by the hot water and acidified with hydrochloric acid; this dish is then placed with the other on the steam bath. When the contents of both dishes are dry, 10 to 15 cc of strong hydrochloric acid are added to the dish containing the residue of the original filtrate. After heating until the ferric salt is dissolved, the solution is evaporated until the excess of hydrochloric acid is expelled, as is indicated by the first appearance of insoluble ferric chloride on the bottom or sides of the dish. Seven cc of strong nitric acid are added and heat is applied for about one minute, or until the violent reaction is over. The solution is diluted with cold water and filtered into a suitable flask. This is the procedure if all the filtrate is to be used for the phosphorus determination; but the evaporation of the excess hydrochloric acid and the addition of the nitric acid are dispensed with if the united filtrates are to be received in a volumetric flask and aliquot portions taken for the other determinations.

To the dish containing the fusion, and which should not be heated above 120° C., just enough dilute hydrochloric acid is added to moisten the residue. Hot water is then added and heat applied until all the salts are dissolved, when the solution is filtered into the same flask with the last filtrate, the combined filtrates should not exceed 150 cc if the solution is to be used for the phosphorus determination. In this case, the complete washing of the silica is continued in another flask until free from chlorides, and these washings are discarded. The filter and its contents are then ignited and weighed as silica. The filtrate in the flask is reserved for the phosphorus determination, or if in a volumetric flask, for the determinations which follow.

Phosphorus.

BY THE FUSION METHOD.

For this determination five grams of the sample are taken

*Note.—This clause is introduced on the insistence of the mine chemists that with certain ores evaporation to dryness is not necessary to obtain all the silica

[illegible] when the phosphorus contents are under 0.100 per cent, [illegible] and one-half grams when the phosphorus contents are between 0.100 and 1.0.200 per cent, and one gram when the phosphorus exceeds 0.200 per cent.

Measure out part of the filtrate, the volume of which should not exceed 150 cc, representing one gram, or two and a half grams of the sample, from the five gram portion for silica in the volumetric flask, is boiled in a suitable flask for a few minutes with the addition of 10 cc of strong nitric acid. To this solution, or to the entire filtrate in the flask from the five gram portion, a slight excess of strong ammonia is added over the amount necessary to precipitate the iron and alumina, and after adding enough strong nitric acid to dissolve the precipitate with from 5 to 10 cc in excess.

The solution is heated to a temperature of 80° C., 50 cc of the solution of ammonia molybdate are added, and the flask is shaken continuously for five minutes. The solution is allowed to stand until the precipitate has subsided. If the yellow precipitate is to be weighed, it is caught on a 9 cm. filter paper that has been dried for at least half an hour at 110° to 120° C. and weighed between watch glasses, washed thoroughly with a 2 per cent solution of nitric acid, dried for one hour at the above temperature and weighed between glasses; 1.63 per cent of its weight is phosphorus.

If the yellow precipitate is to be titrated by the acid alkali method, the weighing of the filter is dispensed with, the washing with the 2 per cent nitric acid is continued as before to the complete removal of the iron and molybdenum salts, and then with a 1 per cent solution of potassium nitrate until free from acid. The filter and its contents are then transferred to a small flask or beaker and an excess of the standard alkali added. When the precipitate is all dissolved by shaking or stirring, about 150 cc of water and a couple of drops of a saturated solution of phenolphthalein in alcohol are added, and the solution is back titrated with the standard nitric acid to the disappearance of the color. It is optional to again add the standard alkali, the end point being a faint, permanent, pink color.

The yellow precipitate may also be dissolved in dilute ammonia, and the phosphorus determined by the permanganate titration method as subsequently described. Or it may be dissolved in a hot ammoniacal citrate solution and the phosphorus precipitated as ammonium magnesium phosphate, as hereafter described.

Ammonium Molybdate Solution: This solution is made in the following proportions. To 225 grams of pure molybdic acid in a suitable flask there is added 500 cc of water, and then 500 cc of strong ammonia. When in solution, this is poured into a flask containing 2500 cc of nitric acid of 1.20 sp. gr., the solution being kept agitated, and three or four drops of ammonium or sodium phosphate solution are added to coagulate the suspended impurities. The solution is kept in a warm place over night or until the supernatant liquid is clear, when it is filtered into a bottle for use.

Stock Solution of Caustic Soda: 145 grams are dissolved in water and the solution is diluted to 2200 cc; 200 cc of this solution diluted to 2000 cc will be of approximate strength.

Nitric Acid: 20 cc of strong nitric acid are diluted to 2000 cc. These solutions are made exactly agreeing, and standardized on steels or ores of known phosphorus contents so that each cc used corresponds to 0.01 per cent phosphorus, when two grams of the sample are used. This weight has been found the most convenient for steel analysis, and a simple calculation enables it to be used for varying weights of either steel or ore.

Phosphorus.

DIRECT DETERMINATION OF THE SOLUBLE PHOSPHORUS USING THE PERMANGANATE OR THE ACID ALKALI TITRATION.

This method is particularly applicable to ores wherein all or a fairly constant proportion of the phosphorus is soluble in strong acid. The insoluble phosphorus is determined at less frequent intervals, and the amount so obtained added to the soluble gives the total phosphorus.

From one to five grams of the sample, according to the phosphorus content, are placed in a beaker with a watch-glass cover, 20 to 50 cc of strong hydrochloric acid are added and a gentle heat is applied until the ore is dissolved. Two or three drops of nitric acid are added and the solution is boiled a minute or two, and then the excess acid evaporated. The solution is diluted and filtered, the filtrate being received in an 8 to 16 ounce Erlenmeyer flask; the filter and residue are washed with dilute hydrochloric acid (1 part acid to 4 parts water) and water until free from iron discoloration.

Strong ammonia is now added until a slight precipitate persists, or until the iron is completely precipitated, and in either case this is dissolved with strong nitric acid, too great an excess being avoided. The solution is heated to 80° C., 30 to 50 cc of ammonium molybdate solution are added, the flask is shaken and placed in a warm place to allow the precipitate to subside. The greater part of the supernatant liquid is siphoned off, the remainder being filtered, or the entire solution is filtered. The precipitate is washed with ammonium sulphate solution or a 2 per cent sulphuric acid solution, until free from iron and molybdenum salts.

The funnel containing the precipitate is transferred to the flask in which the precipitation was made, and the precipitate dissolved in dilute ammonia (1 part ammonia to 3 parts water); the resulting solution should not exceed 25 cc. Eight grams of granulated zinc (20 mesh) are added, then 75 cc of sulphuric acid (1 part acid to 4 parts water), and the solution is boiled gently until reduction is complete. It is then filtered through glass wool or cotton, the filtrate being received in a beaker, and the flask and filter are washed thoroughly with cold water. The solution is titrated with potassium permanganate until a slight, permanent, pink tint is obtained. From the number of cc used, the percentage of phosphorus is calculated.

If the acid alkali titration is to be used, the yellow precipitate is washed as before with a 2 per cent nitric acid solution until free from iron and molybdenum salts, then with a 1 per cent solution of potassium nitrate until free from acid, and the determination is completed in the regular manner.

SOLUTIONS.

STANDARD PERMANGANATE.

204.5 grams potassium permanganate,
1 carboy (48 liters) distilled water.

AMMONIUM MOLYBDATE.

300 grams molybdic acid dissolved in
1200 cc ammonium hydrate, sp. gr. 0.96. This is to be added slowly to
4500 cc nitric acid, sp. gr. 1.20, keeping the solution agitated.

AMMONIUM SULPHATE.

40000 cc distilled water,
1100 cc ammonium hydrate, sp. gr. 0.96,
960 cc sulphuric acid, sp. gr. 1.84.

PHENOLPHTHALEIN.

Saturated solution in alcohol.

Phosphorus.

BY IGNITION OF THE INSOLUBLE RESIDUE.

One to five grams of the sample in a porcelain dish, with watch-glass cover, are digested in 20 to 50 cc of strong hydrochloric acid with the aid of a gentle heat. After diluting slightly with cold water, the solution is filtered into another dish of the same size and the precipitate washed free of the visible iron discoloration. The filtrate is rapidly evaporated and while this is in progress, the residue is transferred to a platinum crucible and ignited in a muffle furnace or over a blast lamp. The residue is broken up, reignited for a few minutes, then transferred into the original filtrate and the solution is evaporated to dryness.

Fifteen cc of strong hydrochloric acid are now added and

the solution is evaporated until ferric chloride begins to separate in the solid state. To the covered dish 7 cc of strong nitric acid are added and heating is continued for about one minute. The solution is diluted with cold water and filtered into a suitable flask. The filter and precipitate are washed with a 2 per cent nitric acid solution until the iron discoloration is removed.

With unknown ores, and at regular intervals with all ores, as a check, the insoluble residue is fused with sodium carbonate. The fusion is dissolved in dilute hydrochloric acid (1 part acid to 1 part water), and the solution is evaporated to dryness. The residue is redissolved in dilute hydrochloric acid and the solution is filtered into the main filtrate, which has also been evaporated to dryness, and the residue treated as described in the previous paragraph after the evaporation to dryness. The filtrate, or the combined filtrates in the flask are made ammoniacal, and the precipitate is dissolved in strong nitric acid with 5 to 10 cc in excess. The solution is brought to a temperature of 80° C., 50 cc of ammonium molybdate solution are added and the flask is shaken for five minutes.

When the precipitate has subsided, it is filtered off and washed with a 2 per cent solution of nitric acid. From this point the yellow precipitate may be weighed, or titrated by the acid alkali or permanganate methods as previously described, or dissolved, reprecipitated, and weighed as magnesium pyrophosphate in the following manner:

The yellow precipitate is dissolved on the filter with hot ammonium citrate solution (175 cc strong ammonia to 325 cc water containing 25 grams citric acid), the filtrate being received in a No. 5 beaker. The filter is washed several times with hot water, then 5 to 10 cc of magnesia mixture (100 grams magnesium sulphate plus 300 grams ammonium chloride in 800 cc hot water plus 400 cc strong ammonia) are poured through the filter. The filtrate in the small beaker is thoroughly mixed and allowed to stand for at least three hours, and if possible over night. The precipiate is filtered off, washed with dilute ammonia (1 part ammonia to 4 parts water), ignited at a low temperature until the carbon of the filter is destroyed, then at the highest temperature of the muffle furnace or burner, cooled and weighed as magnesium pyrophosphate containing 27.84 per cent phosphorus.

Phosphorus.

WHEN TITANIUM IS PRESENT.

Two grams of the sample are intimately mixed with eight to ten times its weight of sodium carbonate in a large platinum crucible and fused over a blast lamp, the fusion being maintained at the highest temperature for fifteen to twenty minutes. The fusion is then transferred to a beaker containing hot water and thoroughly disintegrated; the solution is then filtered and the residue washed with hot water, or preferably with a 1 per cent solution of sodium carbonate. As an extra precaution not deemed necessary in everyday work, the residue may be ignited until the filter is destroyed, crushed in the crucible, fused, disintegrated and filtered off as before, the filtrates being combined. The filtrate, or the combined filtrates are acidified with hydrochloric acid and evaporated to dryness. The residue is moistened with dilute hydrochloric acid, dissolved in hot water and the solution filtered into a suitable flask.

The filtrate is made ammoniacal, then strong nitric acid is added with from 5 to 10 cc in excess. The solution is brought to a temperature of 80° C., 50 cc of ammonium molybdate solution are added, the flask is shaken for five minutes, and the phosphorus determined by any of the methods previously described.

When it is desired to separate the phosphorus from the large amount of sodium salts in the filtrate after the evaporation to dryness, a weighed amount of iron, about 0.05 gram, of known phosphorus content, and in the ferric condition, is added and precipitated in the hot solution with ammonia. The precipitate is filtered off, dissolved in warm dilute nitric acid, and if the resulting filtrate is somewhat cloudy from particles of filter paper in suspension, and it is desired to remove them, it is refiltered after the addition of a little paper pulp. The filtrate is now made ammoniacal, 5 to 10 cc excess nitric acid are added, and the determination is completed as above described.

Alumina.

PHOSPHATE METHOD.

For this determination the hydrochloric acid filtrate from the silica of one gram of the sample, or the hydrochloric acid solution of the precipitated iron and alumina from the gravimetric determination of manganese is used. To the cool solution diluted to about 400 cc in a No. 5 beaker, 30 cc of a 10 per cent solution of ammonium phosphate are added, and then ammonia until a faint, permanent precipitate is formed. One and one-half cc of strong hydrochloric acid are now added, the solution is stirred until the precipitate is dissolved, and 5 cc of a 20 per cent solution of sodium hyposulphite are added. The solution is heated just to the boiling point, at which 8 cc of strong acetic acid and 15 cc of a 20 per cent solution of ammonium acetate in the same measure are added, and the boiling is continued ten minutes. The precipitate is allowed a few minutes to subside, is filtered off as quickly as possible and washed ten times with hot water. The filter and its contents are ignited at a low temperature until the carbon is destroyed, then at the highest temperature of the muffle furnace, cooled and weighed as aluminium phosphate, 41.85 per cent of which is alumina.

Alumina.

ETHER METHOD.

One to five grams of the sample are placed in an 8-ounce beaker and dissolved in 20 to 50 cc of strong hydrochloric acid with the aid of a gentle heat. The solution is diluted and filtered, the residue washed, and the filtrate evaporated to dryness. The residue on the filter is ignited in a platinum crucible, 2 to 6 drops of sulphuric (1 part acid to 1 part water) and 5 to 10 cc of hydrofluoric acids are added and the solution is evaporated to dryness. The residue in the crucible is fused with one-half to two and one-half grams of potassium or sodium bisulphate and dissolved in 10 cc of dilute hydrochloric acid (1 part acid to 1 part water). The residue from the original filtrate, after its evaporation to dryness, is dissolved in 20 to 30 cc of hydrochloric acid, 1.13 sp. gr., cooled and transferred to a separatory funnel, 40 to 100 cc of ether are added, and the funnel is shaken for one minute, the solution being kept cool. The acid layer is drawn off into an 8-ounce beaker, and to this is added the solution obtained from the treatment of the insoluble residue. The combined solutions are heated until the ether is driven off, a few crystals of sodium or potassium chlorate are added, and the heating is continued until free chlorine is expelled. The solution is diluted to about 75 cc, ammonia is added until a slight precipitate persists, then 10 cc of a 20 per cent solution of ammonium acetate. The solution is boiled about one minute and filtered; the precipitate is washed with hot water, then dissolved in warm dilute hydrochloric acid. After being diluted to about 75 cc and a slight excess of ammonia added, the solution is boiled, filtered and the precipitate washed as before. The combined filtrates are reserved for the determination of manganese, lime and magnesia. From this point the alumina may be determined by either of the following methods:

The precipitate is ignited, and weighed as oxides of iron, alumina and phosphorus. The ignited oxides are dissolved in 3 cc of stannous chloride and 10 cc of strong hydrochloric acid, and the iron is titrated with a weak bichromate solution, 1 cc of which is equal to 2 per cent iron. Or the precipitate is fused with sodium carbonate, the fusion is dissolved in hydrochloric acid and the iron titrated as above. The iron calculated as the sesquioxide, plus the phosphorus as pentoxide is

deducted from the total weight of the precipitate leaving the alumina.

Or the filter and precipitate are ignited at a low temperature until the carbon is destroyed. The precipitate is crushed in the crucible and thoroughly fused with about 5 grams of sodium carbonate. The fusion is dissolved in hot water, a little paper pulp is added to reduce any manganese that may be present, the residue is filtered off and washed. The filtrate received in a small beaker is acidified with hydrochloric acid, heated to boiling, and ammonia is added in slight excess. After boiling for a minute or two, the precipitate is filtered off, washed with hot water, ignited and weighed. This weight minus the weight of the phosphorus as pentoxide is alumina.

Manganese.

GRAVIMETRIC METHOD

The filtrate from the one gram portion for silica, or an aliquot part of the filtrate, equal to one gram of the ore, from the five gram portion for silica in the volumetric flask, is boiled for a few minutes in a No. 5 beaker with the addition of 10 cc of strong nitric acid. A basic acetate separation is then made as follows: The solution is diluted with cold water to about 150 cc and the greater part of the free acid is neutralized with strong ammonia, then cautiously with dilute ammonia (1 part ammonia to 4 parts water) with vigorous stirring, until a faint precipitate persists. The solution is then diluted with hot water to about 400 cc, 25 cc of a 20 per cent solution of ammonium acetate are added, the solution is heated to boiling and boiled about one mintue. After the precipitate has subsided, the solution is filtered through a 185 mm filter on a 4-inch ribbed funnel into a No. 6 beaker.

When the manganese is under one per cent, only one basic acetate separation is made and the precipitate is washed several times with hot water. If over one per cent, the precipitate is washed but once, then dissolved on the filter in hot, dilute hydrochloric acid and the basic acetate separation made as before, except that the dilution before precipitating need not be so great. The filtrate and washings, or the combined filtrates in this determination, or from the iron and alumina in the ether alumina method are heated to boiling and 25 cc of strong ammonia added, and then cautiously about 1 gram of ammonium persulphate. One gram is sufficient to precipitate the manganese in any iron ore. The solution is boiled about ten minutes and the precipitate filtered off, wash with hot water, ignited at a gentle heat and then at the highest temperature of the muffle furnace or blast lamp, and weighed as manganomanganic oxide, containing 72.05 per cent manganese. This precipitate may be dissolved before or after ignition, reprecipitated and weighed as manganese pyrophosphate.

The ignited precipitate of mangano-manganic oxide is usually contaminated with a small amount of silica sufficient to cause an appreciable error in a small percentage of manganese. In this case it is dissolved in the crucible in warm, dilute hydrochloric acid; the residue, if any, is filtered off, washed, burned and the weight obtained is deducted from the previous weight.

The precipitate of iron and alumina on the filter obtained in this determination is to be retained for the determination of alumina by the phosphate mtehod.

Manganese.

VOLHARD'S METHOD.

One to two grams of the sample are placed in a No. 2 beaker with cover, 15 to 25 cc of strong hydrochloric acid are added, and heat is applied until the ore is dissolved. Five cc of nitric acid or a few crystals of potassium chlorate are now added, and the solution is boiled until nitrous fumes or free chlorine are expelled. Evaporation is continued to the expulsion of free acid, the solution is diluted to about 100 cc and washed into a volumetric flask. Zinc oxide emulsion is added in excess, the solution is diluted to the mark and mixed thoroughly; the precipitate is allowed to subside and an aliquot portion is decanted off, equal to one-half or one gram of the ore. For ores low in manganese the solution is made slightly turbid with zinc oxide emulsion to coagulate the manganese dioxide set free in the titration. The solution is heated to boiling and titrated with permanganate until a faint, pink color persists. Or, after the dilution to about 100 cc, the solution is washed into a half-liter flask, an excess of zinc oxide emulsion is added as before, the solution is heated to boiling and titrated directly in the presence of the iron precipitate.

Strength of permanganate solution for iron ores: 1 cc equals 0.1 per cent manganese, standardized on iron ore of about ½ per cent manganese content.

For manganese ores the procedure is the same up to the removal of the free acid and the addition of zinc oxide emulsion, when the solution is diluted to the mark in a 500 cc volumetric flask and mixed. Then 50 cc are transferred to a flask, diluted to about 250 cc, heated to boiling and titrated as before. No zinc oxide emulsion need be added here, the voluminous precipitate of manganese dioxide acting as coagulent.

Strength of permanganate solution for manganese ores: 1 cc equals 0.3 per cent manganese, standardized on manganese ore of known manganese content.

Manganese.

COLOR COMPARISON OR TITRATION METHOD.

One gram of the sample in a porcelain dish, or beaker, is warmed after the addition of 25 cc of strong hydrochloric and 5 cc of strong sulphuric acids, and when in solution the heating is continued until fumes of sulphuric acid appear. The solution is allowed to cool, 25 cc of water are added, heat is applied until the salts are dissolved, and the solution is transferred to a 50 cc volumetric flask, diluted to the mark and mixed. If the color comparison method is to be used, the solution should be poured through a dry filter after mixing; if the titration method is to be used, the filtration may be omitted. With a pipette 10 cc, equal to 0.2 gram of the ore, are transferred into a 1-inch by 8-inch test tube, if for comparison, or into a 150 cc Erlenmeyer flask, if to be titrated. Fifteen cc of the nitrate of silver solution are added, the solution is heated over a flame or in a water bath, and about one gram of ammonium persulphate is added. The reaction takes place equally well in a nitric or sulphuric acid solution or a mixture of the two. The essential point is the presence of a sufficient amount of silver nitrate. As soon as the formation of the permanganic acid is well under way, the test tube or flask is removed from the source of heat and placed in a cold water bath. This solution may be compared against the color obtained from an ore or a steel of known manganese content, in the latter case by dissolving 0.2 gram of the steel in 10 cc of nitric acid of 1.20 sp. gr., adding 15 cc of the silver nitrate solution and the persulphate as above.

If the solution in the 150 cc Erlenmeyer flask is to be titrated, it is diluted to about 100 cc, 7 cc of a 0.2 per cent solution of C. P. sodium chloride are added and the sodium arsenite solution is run in until the color is just discharged.

If the insoluble residue is suspected of containing manganese, it is filtered off, burned, 2 or 3 drops of sulphuric (1 part acid to 1 part water) and about 5 cc of hydrofluoric acids are added and the solution is evaporated until sulphuric acid fumes appear; 5 cc of the same dilute sulphuric acid are added, and the crucible is warmed till the residue is in solution, when it is added to the main solution.

The stock solution of silver nitrate is made in the proportion of 66.66 grams of the salt to the liter. Twenty cc of this solution are diluted to one liter for use; each 15 cc contains 0.02 grams of silver nitrate.

The sodium arsenite solution is made by boiling 10 grams of arsenious acid until dissolved in an equeous solution of 30 grams of sodium carbonate and diluting to 1 liter. About 125 cc of the stock solution are diluted to 2000 cc, and this solution

is standardized on steels or ores of known manganese contents so that 1 cc equals 0.1 per cent manganese on a 0.2-gram sample.

Manganese.

PEROXIDE REDUCTION METHOD.

One-half to three grams of the sample in a beaker are digested in 20 to 50 cc of strong hydrochloric acid. If the insoluble residue is suspected of containing manganese, a few drops of hydrofluoric acid are added, and the solution is evaporated almost to dryness. Manganese free glass must be used if hydrofluoric acid is employed. Seventy-five cc of strong nitric acid are added, the solution is boiled until clear, the manganese is precipitated as dioxide by the addition of a slight excess of potassium chlorate, and the boiling is continued for about five minutes. The solution is cooled, diluted to about 300 cc with cold water, and a definite amount of hydrogen peroxide solution is added from a pipette. After the reduction of the dioxide, the excess of hydrogen peroxide is determined by titration with standard potassium permanganate solution. The value of the peroxide solution in terms of permanganate is determined, and from the total volume of peroxide used, less the excess determined by the permanganate titration, the percentage of manganese is calculated.

The relative value of these two solutions is determined as follows: About 60 cc of strong nitric acid are boiled for about five minutes in a beaker, then cooled and diluted to about 300 cc. To the cold solution a definite amount of the peroxide solution is added and titrated with the standard permanganate.

The hydrogen peroxide solution is made by diluting one pound of hydrogen peroxide to 9,000 cc, containing 200 cc of strong sulphuric acid.

The permanganate solution contains 1.7375 grams per liter and is standardized against an ore of known manganese content.

Lime.

The filtrate from the persulphate or bromine precipitation of the manganese, after the basic acetate or ammonia separation of the iron and alumina, is heated to boiling in a No. 6 beaker, 10 cc of strong ammonia and 5 cc of a saturated solution of ammonium oxalate are added, and the heating is continued until the volume of the solution is reduced to about 150 cc. When the lime is low it is essential that the evaporation be continued to this point to insure complete precipitation. Five cc of strong ammonia are now added and the solution is boiled for about ten minutes. The precipitate is then filtered off, washed with hot water, burned and weighed as calcium oxide. In normal ores when the lime and magnesia are low, only the first few washings are allowed to flow into the filtrate, the object being to keep the filtrate as concentrated as possible for the magnesia determination which follows. The calcium oxide is also liable to be contaminated with a small amount of silica, and, when extreme accuracy is desired, the ignited and weighed precipitate is dissolved in warm, dilute hydrochloric acid and the solution is evaporated to dryness. The residue is dissolved in dilute hydrochloric acid, the silica is determined and deducted from the previous weight.

If the lime is to be titrated, it is dissolved on the filter in 25 cc of hot, dilute sulphuric acid (1 part acid to 4 parts water), the solution is diluted with 150 cc of hot water and titrated with permanganate of such strength that 1 cc equals about 0.100 per cent lime.

Magnesia.

The filtrate from the calcium oxalate, which should not exceed 200 cc in volume, is made slightly acid with strong hydrochloric acid, and 5 cc of a 10 per cent solution of ammonium phosphate are added, then to the cool solution 25 cc of strong ammonia, drop by drop, with continuous stirring during the addition. The solution is stirred at intervals for two or three hours, or continuously on a machine for one hour, and if permissible it is allowed to stand in a cool place over night. The precipitate is filtered off, washed thoroughly with dilute ammonia (1 part ammonia to 4 parts water), ignited at a low temperature until the filter is destroyed, and finally at the highest temperature of the muffle furnace or blast lamp, and weighed as magnesium pyrophosphate containing 36.24 per cent magnesia.

Sulphur.

FUSION METHOD.

One gram of the sample is intimately mixed in a capacious platinum crucible with about ten grams of sulphur free sodium carbonate, and not more than a half gram of potassium nitrate. The crucible is heated cautiously over a blast lamp until the fusion is quiet, the last few minutes of the fusion being at the highest temperature of the blast. If sulphur bearing gas is used, the contents of the crucible must be protected from the flame gases with a suitable shield. The fusion is completely disintegrated in hot water, to which a few drops of alcohol may be added to reduce and precipitate any manganese present. The solution is filtered and the residue washed with hot water, or preferably with a 1 per cent solution of sodium carbonate.

To the filtrate, the volume of which is about 150 cc, there is cautiously added a slight excess of hydrochloric acid. The solution is heated to the boiling point, 5 cc of a 10 per cent solution of barium chloride are added, and the beaker is placed on the steam bath or hot plate until the precipitate has subsided. The precipitate is then filtered off, washed with hot water till free from chlorides, burned in an open crucible and weighed; 13.73 per cent of the weight is sulphur.

If the precipitate is suspected of containing silica, which is rarely the case, it can be purified after ignition by adding a drop of sulphuric and 2 or 3 cc of hydrofluoric acids, evaporating and igniting as usual.

If sulphur free sodium peroxide is used for the decomposition of the ore in place of the sodium carbonate and niter, the fusion is made in a nickel crucible with about 5 grams of the peroxide; the remainder of the treatment is the same.

Sulphur.

WET METHOD

Five to ten grams of the sample in a porcelain dish or beaker, with a watch-glass cover, are dissolved in 50 to 100 cc of aqua regia (1 part nitric acid to 9 parts hydrochloric acid) and the solution is evaporated to dryness. The residue is dissolved in 20 to 40 cc of strong hydrochloric acid and the solution evaporated until the first appearance of insoluble ferric chloride. This is dissolved by the addition of a slight excess of strong hydrochloric acid, the solution is diluted to about 75 cc, and filtered into a suitable beaker, the residue being washed with hot water and the least possible amount of dilute hydrochloric acid.

If the insoluble residue is suspected of containing sulphur compounds insoluble in aqua regia, it is fused with the least possible amount of sodium carbonate and niter, as previously described in the Fusion Method for Sulphur. The fusion is disintegrated in hot water, the solution is filtered, acidified with hydrochloric acid and added to the main filtrate, or the sulphur may be estimated separately.

The filtrate is heated nearly to boiling, and after the addition of 5 cc of a 10 per cent solution of barium chloride it is again evaporated until a film of ferric chloride appears. This is dissolved by the addition of a few drops of strong hydrochloric acid and, with a wash bottle, a stream of cold water is forced into the solution until its volume is from 175 to 250 cc. It is then set aside in a cool place over night. The precipitate is filtered off, washed with hot water and dilute hydrochloride acid until free from iron, burned and weighed as usual.

Ignition Loss.

One gram of the sample is placed in a platinum crucible with a tightly fitting cover and ignited at a bright red heat for fifteen minutes. It is then allowed to cool in a desiccator and weighed.

[illegible] is repeated [illegible] ignition until constant weight is obtained.

Moisture.

A portion of the [illegible] sample reserved for the moisture determination, in either case not less than two kilograms, is transferred to a suitable jar and weighed, dried at 100° C. until constant weight is obtained and the percentage of moisture calculated.

Heat Conductivities in the Calculation of Furnaces.

By Carl Hering.

It is well known to all those who have made calculations involving heat conductivities that the necessary constants representing the conductivities or specific conductances are not always to be found in tables, and when they exist, they are not always in the form in which they are wanted. Among the latter cases is the one in which the heat conductivity is given for certain different ranges of temperature, as, for instance, from 0° to 500° C., and from 0° to 1300° C., but not for the range between the two high temperatures. This constant represents the mean value when the stated temperatures are the two given extremes.

It not infrequently happens that this mean is required for a range between the two higher temperatures instead of from 0° up. For instance, it is customary, and very good practice, to use one kind of heat insulating material for the inner lining of a furnace, choosing it for its refractory property, and a different material for the outer layer of the furnace wall, selecting it for its heat insulating property. This is due to the fact that materials which are very refractory are not always the best heat insulators. Infusorial earth, for instance, is an excellent heat insulator at the lower temperatures, but loses this property at very high temperatures; while firebrick, suitable for very high temperatures, is a good refractory material, but is not nearly as good a heat insulator for the outer portions of the furnace as infusorial earth is.

In calculating the heat losses by conduction through the walls of such furnaces, made of several materials, as, for instance, firebrick on the inside and infusorial earth on the outside, it is necessary to know what the heat conductivity is for firebrick between two high temperatures, and the figures in the tables are not generally given in that way. The purpose of the present article is to show how this may be calculated correctly from given data and without assuming any particular law of variation. The importance of calculating it instead of the more usual practice of guessing at it is shown by the rapid rise of this constant with increasing temperatures.

The calculation, is, of course, limited to the ranges given in the tables. If, for instance, the heat conductivity for firebrick is given as 0.0014 as a mean from 0° to 500°, and 0.0031 as a mean from 0° to 1300° C., it is possible to calculate correctly the corresponding figure between the two given high temperatures, 500° and 1300°. These particular values are in the c.g.s. system and mean the calories per second which will pass through 1 cm of the material, 1 sq. cm in section, for a difference of 1° C. between the two surfaces.

Let k be this heat conductivity for the lower range of temperature, t, and K the corresponding figure for the higher range T; let t' and T' be the two maximum temperatures of the ranges t and T respectively; and let H represent the heat in calories per second passing through a body. For 1 cu. cm

$$H = kt.$$

Assume another piece of the same material, also 1 cm cross section, and of such length L, that it will conduct the same quantity of heat, H, when its ends have the temperatures 0° and T° for which the mean conductivity is K. For this rod

$$H = \frac{KT}{L},$$

but as the heat flow H is by definition the same in both, it follows that

$$kt = \frac{KT}{L} \qquad (1)$$

In the accompanying diagram the first rod is represented by the small cube, and the second one by the long rod.

Now, let x be the quantity desired, namely, the mean conductivity between the two higher temperatures t' and T'. It will be seen from the diagrams that, as the flow of heat is the same in both, it necessarily follows that the longer rod will have a temperature of 500° at a distance of 1 cm from the cool end, because that last centimeter must be under precisely the same conditions as the cube above, in order that the flow of heat is the same. Hence, it follows that there will be a fall of temperature from T' to t' over a length of this rod equal to $L - 1$; and as the heat flowing through this portion is the same as through the whole rod, it follows that

$$H = \frac{x\,(T' - t')}{L - 1} = kt \qquad (2)$$

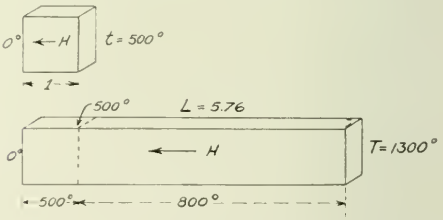
Eliminating L from equations (1) and (2) and solving for x gives the desired quantity

$$x = \frac{KT - kt}{T' - t'}$$

Applying this by illustration to the above data for firebrick, it will be found that

$$x = 0.00416,$$

which, therefore, is the mean heat conductivity of firebrick for the range 500° to 1300° C.



CALCULATION OF HEAT CONDUCTIVITY BETWEEN CERTAIN TEMPERATURES.

Incidentally, it may be of interest to solve equation (1) for L, and it will be found to be 5.76 cm. The two rods in the above diagram have been drawn to scale. The diagram, therefore, shows graphically what a very large amount of firebrick is necessary to reduce the temperature in the walls from 1300° to 500° (namely, 800°), and what a relatively small thickness is required for the remaining 500°. This, of course, is due to the fact that firebrick rapidly loses its insulating properties at high temperatures. It shows how important it is to have as thin a layer of firebrick and as thick a layer of infusorial earth as possible, the relative amounts depending upon the maximum temperature at which the high insulating material will retain its good quality.

The Use of Lime and Increased Temperatures in Cyanidation.

A recent paper of Mr. Leo D. Bishop, metallurgist with the Hendryx Cyanide Marchinery Co., of Denver, Col., presented before the Colorado Scientific Society and published in full in the *Proceedings* of this society, Vol. IX, page 99, deals in a very interesting manner with certain special features of the cyanide process, especially with the effect of alkalis in conjunction with cyanide solutions, the selection of the proper alkalinity, the choice of the lime and the necessary care in its handling and use, and finally with the effect of heat and motion on the dissolution of gold from ores.

Use of Alkalis with Cyanide Solutions.—Most all ores which are amenable to the cyanide process contain both free

and latent acids, which destroy cyanide. Consequently, a protective alkalinity must be maintained to prevent the useless consumption of cyanide. Alkalis must also be used for the purpose of hastening the filtration of solutions, especially where there is any appreciable amount of slime or finely ground ore.

For the purpose of settling slime, it is not necessary that an alkali or hydroxide be used. More effective settlement can be had by the use of distilled water than either the use of acid solution or hydroxides. Sodium hydroxide produces a coagulation of the slime and a rapid and compact settlement, but leaves a poorer clarification than lime. However, when properly slacked lime is added to the slime, a flocculent effect is obtained and the slime coagulates into a flaky curd, which does not settle out so compactly by gravity, but does leave a clearer and more brilliant solution than either sodium hydroxide or acids.

It is not necessary for the purpose of settlement that the slime be coagulated. In fact, it is oftentimes injurious for this purpose that lime be added. It is necessary, however, that lime be used and the slime coagulated for the purpose of rapid and clean filtration. In fact, it is almost an absolute condition precedent that every particle of slime be completely coagulated in order to get the most rapid filtration and a clear solution suitable for good precipitation.

Mr. Bishop has carried out some interesting experiments with a sample of ore furnished by the Creston Colorado Co. at Minas Prietas, Sonora, Mexico, which was completely oxidized and siliceous in character, containing a high percentage of slime. This ore was ground in a tube mill until it all passed a 200-mesh screen. In all cases a sample of two parts by weight of solution to one of ore was made and allowed to settle for one hour at different temperatures and with different additions of lime.

The results of these experiments are given graphically in Mr. Bishop's paper, but for the sake of brevity we have condensed them in the following table, showing the amount of lime added, the temperature at which the experiment was made and the degree of settling. The latter is given in the last column. If the last column states, for instance, 18 per cent, it means that after settling for one hour 18 per cent of clear solution was obtained. The degree of settling is, therefore, represented by the percentage of solution which has become clear.

2 solution + 1 ore.....	70° Fahr.	18 per cent clarified
2 solution + 1 ore + 0.5 lb. lime per ton	70° "	18 " " "
2 solution + 1 ore + 0.5 lb. lime per ton	90° "	24 " " "
2 solution + 1 ore + 0.5 lb. lime per ton .....120°	"	30 " " "
2 solution + 1 ore + 1.5 lb. lime per ton	70° "	10 " " "
2 solution + 1 ore + 1.5 lb. lime per ton	90° "	12 " " "
2 solution + 1 ore + 1.5 lb. lime per ton .....120°	"	18 " " "

The results show clearly that a large excess of lime hinders the settling of the slime, while an increase of temperature greatly aids settlement.

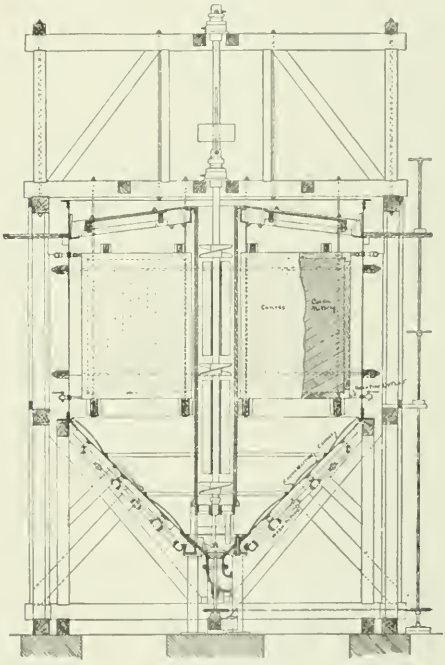
The author then made experiments to determine the effect of heat on the filtration of slime. He used a filter cell of the Hendryx type, as shown in the adjoining figure. This cell is composed of an open frame, with a canvas covering and a layer of cocoa matting between the two canvas sides. Vacuum was not used in these tests, gravity alone sufficing.

In the three tests, the excess lime was 0.50 lb. per ton of solution, and the pulp was two of solution to one of ore by weight. The amount of pulp used in each test was the same, with all conditions identical except a variation in temperature.

At a temperature of 70° Fahr. filtration of the solution was made at the rate of 8¼ lb. solution per hour per square foot of canvas. At 90° Fahr., or a raise of 20°, the rate was more than doubled, the flow of solution reaching 18 lb. per square foot of canvas per hour, and at 110° Fahr. filtration was made at the rate of 24¾ lb. per hour per square foot of canvas. In other words, with the temperature increased 40° the rate of filtration was increased just three times.

It is evident that an increase of temperature has a very pronounced effect on the filtration of slimes. A greater part of the success of some of the present filter systems is no doubt due to an increase of temperature in the mill solutions.

Proper Alkalinity, Choice and Care of Lime.—The question as to the most economical and satisfactory neutralizer must depend almost entirely on the ore which is being treated. Only by making comparative tests as to the percentage of extraction, the consumption of cyanide and the cost per ton of ore for



HENDRYX FILTER AGITATOR.

neutralization can this be determined intelligently. Moreover, the effectiveness of precipitation is also too often influenced by the character and quantity of lime used.

Some ore show an appreciable advantage in extraction by using sodium hydroxide in conjunction with lime, thereby obtaining an increased extraction and a less consumption of cyanide. A sample of ore from Black Hawk, Col., gave an extraction of 11.9 per cent with a loss of 4.10 lb. cyanide per ton using both lime and sodium hydroxide as neutralizers. Where lime alone was used the extraction was lowered to 59.7 per cent, and the consumption of cyanide increased to 6 lb. per ton of ore. In this case, the use of 1.50 lb. of sodium hydroxide per ton of ore raised the extraction 12 per cent and lowered the loss of cyanide 1.90 lb. per ton of ore.

In the choice of lime and the necessary care in its handling and use there seems to be an almost utter disregard. Rarely any thought is given the choice of lime. Many operators class all lime as good lime, and let it go at that. In one mill where a large tonnage of ore is run it was discovered that fully 33 per

cent of the consumption of cyanide was due to the impurities and cyanicides in the burned lime itself.

The cost of treating ore by the cyanide process is increased probably more by the unintelligent handling and use of lime than by any other one item. Many operators to-day allow their lime to become partially air slacked before using. After standing exposed to moisture and air, it is then fed in with the ore and drowned with an excess of cold solution.

For the purpose of illustration, the author has taken a Missouri lime, thoroughly calcined. The first sample of this lime was exposed to the air until it became partially air slacked; 0.25 lb., with 1 lb. of water, were then boiled for five minutes, after which the soluble calcium hydroxide was washed out by decantation with a large excess of cold water. The residue after drying amounted to 12.5 per cent.

Another sample of 0.25 lb. of the same partially air-slacked lime, with 10 lb. of water at 65° Fahr., was allowed to stand for three days with occasional stirring. The soluble calcium hydroxide was then washed out with an excess of cold water. After drying, the residue amounted to 35 per cent of the original amount.

The conclusion arrived at from these two tests shows that fully 35 per cent of the weight of the lime is lost by allowing it to become partially air slacked and then to attempt to slack the remainder by means of a large excess of cold water.

For the purpose of comparison the next tests were made on lump lime ground to pass a 1/3-in. mesh screen. In the first case 0.25 lb. of lime was placed in 20 lb. of water at 65° Fahr., and allowed to stand for three days, with occasional stirring. The soluble hydrate was then removed with an excess of cold water and the residue dried; 25 per cent of the whole amount remained.

In the second case 0.25 lb. of crushed lump lime was mixed with 1 lb. of water. In four minutes the whole mass had reached the boiling point, due to chemical action, and had become almost thoroughly converted from the oxide to the hydrate. There were no lumps or grains left unslacked. The chemical action was practically complete, and a rich, thick paste was the result.

Settlement and filtration tests were then made on the lime water taken from the partially air-slacked lime, the cold-water-slacked and the hot-water-slacked. The pulp in each case was three of solution to one of ore, and the temperature was 70° Fahr. The partially air-slacked lime caused the slime to settle 115 cc in a 500-cc cylinder, or 23 per cent in one-half hour. The same solution filtered at the rate of 22 lb. per square foot of canvas per hour in a Hendryx filter by means of gravity.

The cold-water-slacked lime produced a settlement of the slime of 190 cc in a 500-cc cylinder, or 38 per cent in one-half hour and a filtration of 23.3 lb. solution per square foot of canvas per hour in a Hendryx filter by means of gravity.

The hot-water-slacked lime caused the slime to settle 215 cc in a 500-cc cylinder, or 43 per cent of the whole volume, in one-half hour and produced a filtration of 23.75 lb. solution per square foot of canvas per hour. The properly treated lime causes the solids to settle almost double the amount that the air-slacked does and also filters somewhat faster.

From the foregoing results the question of the proper coagulation of the slime by means of calcium hydroxide is a very important one when one comes to either the settlement or filtration of ores. Moreover, the application of heat is beyond a doubt economical and beneficial

Effect of Heat and Motion on the Solution of Gold.—The final part of Mr. Bishop's paper deals with the dissolution of gold from ores as effected by heat and motion. Quite a complete line of experiments was carried out by T. H. Plunkett, of Toronto, Canada, on the rate of dissolutions of particles of gold ranging from 70 mgs to 8.9 mgs in weight, by means of percolation, agitation, and agitation and heat. A particle of gold weighing 70 mgs was dissolved completely in 72 hours by percolation. A same sized particle was dissolved in 16 hours by agitation and another of similar size in 10 hours by means of agitation and heat. However, these sized particles of gold would not reach the cyanide tanks in practice, but would be caught by amalgamation at the start.

It has been a common belief among cyanide men that the richer the ore, the longer the time of treatment necessary. Perhaps this is true in the usual methods of percolation. By means of complete and thorough agitation it is not necessarily true.

A sample of ore was furnished by Dr. D. H. Dougan, of Denver, consisting in character of white quartz with the gold physical free, assaying $2,500 gold per ton. This ore was pulverized to 200 mesh and the coarse gold removed by amalgamation. The tailings after amalgamation assayed $725.00. With an excess of cyanide strength of 0.75 per ton of solution and constant and thorough agitation for a period of only nine hours the tailings were reduced to $1.60 per ton. These results are not difficult to explain when we consider the fact that all the particles of gold remaining after amalgamation were exceedingly small and not any larger than if the ore had assayed only $25 instead of $725 per ton. The cyanide solution was dissolving each and every particle of fine gold during the period of nine hours.

Another advantage of quick treatment is clearly shown in a test made on some 20-mesh tailings furnished by Mr. W. O. McFarlane, of Denver, from the Ajax mine in New Mexico. These tailings contained a small percentage of iron sulphides. When this ore went into the leaching tanks it assayed approximately $28 gold per ton. After six weeks percolation only $1 per ton of ore was recovered. A sample of tailings from the top of the tanks was taken which went $18.40 per ton.

Without regrinding, this sample was agitated in a Hendryx agitator for a period of eight hours. The tailings then went $9.60, representing a saving of 47.8 per cent of the value of the tailings after six weeks leaching. Another sample was then reground to 150-mesh and yielded readily 93.4 per cent in four hours' agitation.

The fact that the gold had not been recovered by percolation was accounted for by several different reasons, until an examination and an assay of each foot of tailings in the leaching tanks has been made. It was then discovered that the gold has re-precipitated. The assays showed an increase of value ranging from the top of the tank to the bottom.

Moreover, quick treatment by means of agitation effects a considerable saving in cyanide consumption, especially where there is a considerable amount of sulphides. A lot of ore furnished by the Star of the East Gold Mining Co., consisting chiefly of iron sulphides, gave an almost complete extraction at 100 mesh in six hours by means of agitation and heat (90° Fahr.), with a loss of 1.35 lb. cyanide per ton of ore. This same ore yields a somewhat less extraction in six days' percolation with a consumption of cyanide ranging from 0.50 to 0.75 for each succeeding day after the first. The continual decomposition of the sulphides will, and does, produce a loss of chemicals varying with the time of treatment.

In the discussion which followed the paper, Mr. Comstock suggested that the increased rapidity of settling at higher temperatures may be explained by the decrease in viscosity of the water with increase of temperature. This is apparently confirmed by the fact that the observed volumes of clear solution in Mr. Bishop's experiments are nearly inversely as the coefficients of viscosity at the temperatures of the observations.

Nitric Acid from Air.

A paper by W. Cramp and B. Hoyle was presented in December before the British Institution of Electrical Engineers on "The Electric Discharge and Production of Nitric Acid." The authors briefly review the apparatus used by previous investigators, all of which have been mentioned before in this journal; they then describe experiments of their own.

Their apparatus is shown in Fig. 1. It consists of a high-tension transformer excited by means of an alternator and used

to feed on its high-tension side a pair of phosphor-bronze ribbon electrodes shaped almost like the well-known horn lightning arresters.

The nozzle *A* is supplied with air from an air pump and receiver, so that the air has time to cool after being compressed before issuing from the nozzle. The alternator used by them is a "Cramp self-excited" machine with a drooping characteristic and a frequency of 160. The transformer has a ratio of transformation of 100 to 1.

In the left-hand diagram of Fig. 1 *A* is the "Laval"-shaped glass nozzle, *B* the electrodes, *T* the transformer (ratio 100 to 1), *E S V* an electrostatic voltmeter on the high-tension side, *A* and *V* low-tension ammeter and voltmeter, *G* the air-pressure gauge, *O* the air outlet, *P* the air pump, *R* the air receiver, *F R* the field rheostats, *F F* the exciter and alternator field coils, *E* the exciter and *S* the stator of the alternator.

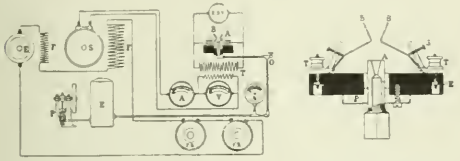


FIG. 1.—APPARATUS FOR FIXATION OF ATMOSPHERIC NITROGEN.

The details of the sparking electrodes are shown in the right-hand diagram, in which *A* is again the aluminium Laval nozzle, *B* are phosphor-bronze sparking ribbons, *P* an aluminium plate, carrying the ebonite base *E* and adjustable on *A*, while *T* are the terminals and *S* the screw adjustment for gap length.

The chief value of the paper appears to rest in the general consideration of the various forms which electric discharges assume, and which are classified as follows: glow, brush, spark, nitrogen flame (high-tension), and arc (low-tension).

By gradual increase of the current supplied to the low-tension side of a transformer, a spark between points on the high-tension side can be caused to pass through every form successively in the order: glow, brush, oscillatory spark, nitrogen flame, and flaming arc.

A curve for a discharge regulated in this way is shown in Fig. 2, where with gradual increase of pressure across a pair of points, a glow is formed in the region from *A* to *B*. At *B* a brush discharge is set up, which gradually passes between *B* and *C* into the oscillatory discharge or spark.

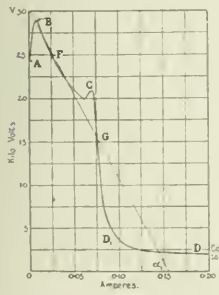


FIG. 2.—CURVES FROM PRIMARY SIDE OF TRANSFORMER.

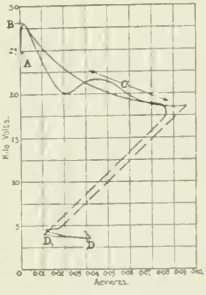


FIG. 3.—CURVES FROM SECONDARY SIDE OF TRANSFORMER.

At *C* the latter breaks down into the high-tension arc or nitrogen flame, which continues to exist with great fall of pressure to the point *D*, after which the discharge is of the character of the ordinary low-tension arc.

These characteristics and curves are correct so long as measurements are made on the low-tension side of the transformer, but if the readings of pressure and current be taken on the high-tension side, it is found that the transformer itself has considerable influence on the form of discharge.

In order to test this, readings were taken with a 30-kw, 100,000-volt, core-type transformer. One series of results obtained is plotted in Fig. 3, where the letters used agree with those in Fig. 2. The great difference between Figs. 2 and 3 lies in the fact that the line *B C* is so much longer and so much more horizontal, and that *C D* has a negative slope in Fig. 3.

An elaborate study of this and other experiments has led the authors to the following conclusions: (1) That each particular form of discharge is distinct from the others in having a different ratio of increase of potential *V* to the simultaneous increase of current *A*. (2) The glow discharge is the only one that, throughout its range, shows no negative ratio. (3) All the other forms have first a negative ratio, and then, usually, a positive ratio, as the current is steadily increased. (4) The form of discharge with the biggest negative ratio is the third form, the high-tension arc or nitrogen flame.

The authors, therefore, propose the following definitions: The silent discharge, or glow, shall mean the first discharge taking place between the electrodes in air, whose characteristic ratio[1] is all positive. The brush discharge shall mean that discharge taking place with a hissing noise accompanied by light purple-colored streamers projecting from the electrodes, but not joining them. In this form of discharge the characteristic ratio is nearly all negative. The spark discharge shall mean that discharge which succeeds the brush discharge, and whose characteristic ratio is first negative (advanced brush discharge) and then usually positive. The high-tension discharge, or nitrogen flame, shall mean that discharge which, as the pressure is further increased, follows the sparking discharge, and whose characteristic ratio is first negative and then positive. The low-tension arc shall mean that discharge which exists when the current is carried by the vapor of the electrodes and the spectrum is predominantly that of the material of the electrodes. Its characteristic is first negative and then positive

The chemical characteristics of the five forms are fairly clearly marked. The glow and the brush discharges produce mainly ozone. The disruptive or spark discharge also produces a large proportion of ozone with a sensible proportion of oxides of nitrogen.

The arcing flame is made up of arc-threads carried into this shape by the action of the heated air to which it gives rise. It has a temperature far greater than the above, and is composed mainly of burning nitrogen, as is evident from the fact that a bottle inverted over the flame collects the well-known brown fumes of NO_2. There is no smell of ozone with this discharge.

The well-known low-tension alternating-current arc differs from it in the fact that the conducting part is mainly composed of the vapors of the material of which the terminals are composed.

The effects both of a current of air blowing on the discharge or of a magnetic field across it are the same effect so far as the form of discharge is concerned, for they tend to cause any small arc set up to travel rapidly at right angles to the field or along the line of the air stream. Consequently, the instant an arc is formed it travels away from the point of formation, under the influence of the air stream or the field, getting longer as it proceeds, and probably smaller in cross-section. This continues until it becomes of a length such as the terminal pressure will no longer support, when it is suddenly extinguished and another starts from the points.

Across the points themselves with this form of discharge, there always exists the blue line of the oscillating spark, which continually renews the arc-thread. The effect of the traveling of the threads is to increase the mean length of the discharge

[1] Meaning always the differential quotient of the voltage *V* with respect to the current *A* or the ratio of the increase of *V* to the simultaneous increase of *A*.

pressure across it likewise rises for a given current. [illegible] such a discharge does not necessitate anything [illegible] the same amount of external resistance or reactance as in [illegible] with a discharge of similar type without the air [illegible]

[illegible] that an increase in the capacity of the circuit was found to be somewhat similar to an increase in the blast pressure, and tended to increase the oscillatory current flowing [illegible] air-gap, and to make the discharge yield ozone if it was [illegible] only being given off.

A long series of experiments was made with a view to determining the effects on the chemical results of the use of [illegible] of different diameter, of change of current, of change of air velocity, of alteration of spark-gap length, and of change of capacity of the circuit.

The comparison of these variables was carried out as follows: One variable having been decided upon, everything else in the circuit was kept constant. The air which passed through the discharge had a free exit, and a known portion of it was drawn off at a known rate by means of an aspirator through a flask containing a weak solution of caustic soda of a known strength. This solution contained a little phenol-phthalene as a color indicator. As the gas was bubbled slowly through the flask the absorption of the oxides of nitrogen caused the indicator to lose its color. The time taken for the color to disappear completely was taken as a measure of the amount of acid produced in that time.

Regarding the size of the jet, it was found that the greater the amount of air passed by the jet for a given pressure, the greater is the maximum acid output, and the greater the amount of air passed by any given jet, the less is the maximum acid concentration. From this it follows that with increased quantity of air the amount of acid produced increases faster than the concentration diminishes, and therefore for a large yield per kilowatt-year with such an apparatus, a nozzle giving low concentration will probably be necessary.

Experiments with variations of current, air-gap length, and quantity of air passed indicated that increase of current gives an increased yield up to a certain maximum for each length of gap, and that the greater the quantity of air passed through the gap the higher is this maximum for each gap. In the course of these experiments the influence of the capacity of the electrostatic voltmeter on the secondary side was incidentally shown to be very marked.

The effect of frequency was much complicated by the presence of sharp peaks on some of the curves due to resonance effects. In this connection it was noticed that the higher the blast pressure, the more pronounced is resonance at certain currents, and that the higher the blast pressure, the higher is the value of the current at which oscillations are set up, and the more prominent they are.

The authors, while unable to give definite conclusions as to the effect of variations of frequency, think that it must also be allowed that the presence of a high frequency, in so far as it admits of large capacity currents across the arc and probable production of ozone, is to be considered on the whole as likely to increase the yield of peroxide. Consequently, they conclude that Kowalski and Moscicki are probably right in their statement, but that the reason for the increase in the output is not to be found in the actual increase of frequency, but rather in the increase of ozone due to this frequency, as shown below.

On the appearance of the discharge the effect of the voltmeter capacity, already alluded to, is very marked. It causes the [illegible] oscillatory discharge, which always exists across the [illegible] to be much enlarged in thickness and brilliancy, though the [illegible] of the nitrogen flame is hardly increased. This would agree with the theory that part of the peroxide is due to the splitting up of ozone. Photographs of the discharge were shown which estimated the effect of adding the voltmeter very clearly. Since [illegible] is given off in the lower portion of the discharge is more active than ordinary oxygen, it is reasonable to suppose that more nitrogen will combine than before to form nitrous products.

Further confirmation of this view was obtained from a spectroscopic examination of the discharge, and a glass tube of small diameter was inserted into the high-frequency oscillatory portion of the discharge. Gas was then drawn off and tested, and was found to be rich in ozone. By suitably placing the tube in the discharge, air mixed with ozone could be obtained, while higher up in the same discharge air mixed with nitrogen oxides was obtained.

Some experiments were also tried with reference to the ionization of the gases after formation. In the first place, it was found that the output could be sensibly improved by sudden cooling of the gases after leaving the apparatus, and a Tesla coil was connected to metal plates, between which the gases had to pass on their way to the testing apparatus, which showed that an increased output may be expected of from 5 to 20 per cent, depending upon the conditions existing. The authors' explanation was that when ionized molecules of oxygen and nitrogen pass through an electrostatic field, some of the uncombined elements may be forced together with such a velocity that chemical combination takes place between them. In this way an additional amount of peroxide is formed.

In the concluding portion of the paper the authors endeavor to show that the whole of the electrochemical phenomena discussed may be explained on "recognized ionization and electrochemical hypotheses."

As regards practical deductions, attention is called to the great importance of adapting gap, current and air blast to one another; for it is evident that changes of yield to the extent of 50 per cent or more may be obtained by slight variations of either factor from the best obtainable.

Again, it may be noticed that as regards quantity of air forced through the flame the maximum acid yield does not for a given current occur at the same point as the maximum acid strength; consequently there is a reason to doubt the value of using a magnetic field (as does Birkeland) to spread out the flame. It would appear from rough estimations made on the Birkeland Eyde process as if the efficiency of this system was such as to lead to the belief that a very good proportion of the maximum possible yield was being obtained.

This is a most important point, for if this be true then it is hardly possible to compete with the cyanamide process in point of view of cost. If, on the other hand, by making use of the most favorable velocity, the most favorable gap-length, the introduction of ozone, the instantaneous cooling of whatever gas is produced, and fixing by subsequent ionization, much better yields may be expected, then it is well worth while proceeding on these lines in a large plant with the object of rendering the production of NO more economical.

The United States Patent System Before the American Chemical Society.

The meeting of the New York Section of the American Chemical Society, on Jan. 8, was of unusual and particularly broad interest, as the general subject of discussion was "The United States Patent System, Its Use and Abuse." The chairman of the New York Section, Dr. Leo H. Backeland, presided.

The introductory paper was presented by Mr. F. I. Allen, late United States Commissioner of Patents, who gave a historical and descriptive sketch of the early development of the patent system, and discussed the psychology of the inventor, comparing him with a poet.

Mr. W. Hastings Swenarton, of the New York bar, late of the Examining Corps of the United States Patent Office, discussed, "patents, trade secrets and trade names as factors in industrial development—their relative functions."

The general conception of our laws relating to patents is that of statutes of monopolies. But a patent is not a true monopoly.

The United States patent system comprehensively protects in

ventions which are disclosed, through its letters patent, and to a lesser degree through its caveats. Similarly, its certificates of registration more adequately secure trade marks to their respective owners or proprietors. Trade marks, as well as trade secrets, in addition to the protection afforded by the United States patent system, have long been recognized under the common law as property rights.

While both trade secrets and trade marks are of ancient origin, the legal recognition and protection, under the common law, of trade marks, long preceded that of trade secrets. In fact, it is virtually but a century since the courts have extended their protecting arm to cover the property rights known as trade secrets.

The trade mark is a development of the ancient shop sign. The psychological effect of a trade mark may be immense, as is exemplified by the name "Uneeda."

A trade secret may comprise a process which produces an old product that is producible by other known methods in so nearly an identical condition as to prevent the determination of the method of production, even when the product is subjected to the most careful scrutiny. A typical example of the type of process which one must perforce protect as a trade secret, or else dedicate to the public by virtue of the fact that it is not susceptible of patent protection, is the electrolytic process of treating tin scrap.

No secret can be considered as coming under the protection of the common law unless it is really treated as a secret as such, and unless all parties who are cognizant of it, know that it is secret. It need not, so far as the present status of the law on this subject is concerned, be either new or sufficiently novel to be patentable.

It is often a nice question for a manufacturer to determine whether to protect his invention as a trade secret or to procure a patent thereon. The mere fact that a second inventor may at any time enter the field and apply for, and secure the grant of, a patent is a matter of serious import and worthy of the most careful consideration. This has occurred often in the past, and for this reason, it is in some cases advisable to file a caveat in the confidential archives of the Patent Office, renewing it from year to year as its term expires.

Of course, the caveat should contain as full and complete a description as any patent specification, if one would insure himself against the grant of a patent to a subsequent applicant, and since most trade secrets are carefully guarded in some secret archives, commonly of a corporation, it is obvious that no rights are sacrificed by the filing of a caveat as aforementioned.

Patents and trade marks have a considerable moral effect on the public in general and on competitors in particular. This is even true for "paper patents" and "paper trade-marks."

* * *

Mr. LOUIS C. RAEGENER, of the New York bar, spoke in a very forcible and interesting manner on "some defects in the practice of our patent system, and suggested remedies."

Having been a successful lawyer in patent cases (in many of the most important ones in the past decades), he said he was now taking "a position somewhat similar to that of the illustrious Andrew Carnegie. After the tariff had given him personally all the protection he required, he came before the world and proved that protection for him at least was no longer necessary."

In Mr. Raegener's opinion the practice and procedure of trying a patent case is antiquated, time consuming, abnormally expensive and generally unsatisfactory. Final judgments are practically unobtainable, and pecuniary judgments so rare that any well advised infringer need hardly fear them.

To get the testimony in a patent suit ready for the court takes from a year to 18 months. Testimony is taken at a lawyer's office, usually on the typewriter. If taken stenographically, the stenographer benefits more by that method than the lawyers, because the lawyers and experts, as a rule, charge per diem, and, of course, the longer it takes, the more per diems.

The worst feature is the practical impossibility to stop either the witness or counsel from padding the record with testimony that would never be admissible were the trial in open court and questions could be ruled upon forthwith. It is not unusual for an expert witness to favor the court with his views on the witness stand for weeks and months at a time—"and, by the way, eminent counsel once defined an expert to be one who swears expertly."

It is not at all unusual for a suit involving fairly important issues to cost each side at the rate of from $10,000 to $20,000 per year. After all the testimony has been taken it is printed, an oral argument takes place, printed briefs are submitted, "and after the close of the arguments, if not before, the court goes to sleep, forgets the oral arguments, and after the lapse of considerable time renders an opinion resulting in a decree dismissing the complaint or directing an injunction and an accounting."

There is usually a stay of the accounting pending an appeal by the unsuccessful party to the Circuit Court of Appeals for that circuit, and if the decree of the court below is affirmed, testimony for an accounting is taken before a master and again all the elements combine to protract examinations and increase expenses. Except in extraordinarily important cases it is best to drop the accounting. The defendant is usually an irresponsible corporation or has lost or burned his books of account.

But the trouble does not end here. There is one United States, but there are nine Circuit Courts of Appeal of the United States of co-ordinate jurisdiction. For instance, the Second Circuit takes in New York, Connecticut and Vermont, but New Jersey and Pennsylvania are in the Third, and what is law in the Second Circuit in any particular case is not necessarily law in the Third, as the latter tribunal will frequently—"always with a heavy heart, however"—come to a diametrically opposite conclusion from that reached by the Second.

Therefore, if one gets an injuction in New York, say, against the "Excelsior" corporation, with a capital of $500, the incorporators can go to Hoboken and incorporate as the Hoboken Excelsior Co., and the whole lawsuit has now to go on all over again.

There is a possibility to petition the United States Supreme Court to review a decision of the Circuit Court of Appeals, but as this tribunal is exceedingly busy, most of such petitions are denied without an opinion, and "the result is that whenever a diversity of opinion exists between two Circuit Courts of Appeals as to the validity of a patent, and a petition for certiorari is denied you can keep on litigating and guessing which of the two courts is right, and the chance is one guess will be about as good as the other."

There have been attempts to create one Court of Appeals at Washington to which all appeals in patent cases would lie; but as the creation of such a court means the dispensation of patronage, Mr. Raegener thinks that another decade or so will expire before such an improvement can go into effect.

All judges are honest and learned, but the capacity and ability of judges in patent cases is "as varied as the colors of the rainbow."

"The patent lawyer is, indeed, inexperienced and careless if he does not carefully select his tribunal, so far as it is possible. For among the judges there are some who are so opposed to monopolies and patents that a mere look at the red seal and blue strings of letters patent incite them to such wrath that the patent is instantly doomed.

"Please don't think for a moment that this is a joke, because nobody has ever yet been able to define what is invention or discovery, and how much or how little genius must be shown, how laborious and how brilliant the work must be to dignify it with the name invention, and therefore any learned judge can always decree that the claims of the patent are void for lack of patentable novelty, and no tribunal can really settle that question in any particular case except a court of last resort like the United States Supreme Court.

"An infringer is called a tort feasor, and that is a bad

enough, rather, that a contributory infringer is the worst specimen of humanity imaginable." This theory of contributory infringement is, like alfalfa or Indian corn, the peculiar growth of our country.

"Under the law as made by the courts to-day you can sell your patented engines, your aluminium, your carbide and other patented products upon condition that the purchaser, as long as he uses your patented device or process, shall buy his flour, eggs, oatmeal or soap, his rat traps, furniture or whatever you please from you or your agents, and if any wicked provision or hardware dealer should be mean enough to sell any of these articles to your vendees with knowledge of these restrictions he becomes a contributory infringer, and you can annoy him and make him account for your losses.

"This country never does anything by halves. It gives the worst protection possible to the patentee seeking to enforce the rights plainly given him by the statutory law; on the other hand, by trick and device not found in the statutory law or in the patent laws of any other country, it enables him to hamper trade in the most beautiful manner possible.

"Of course, this theory of contributory infringement does much to make patent laws unpopular, and in the end the honest patentee will suffer."

As to remedies, Mr. Raegener emphasized that in England all patent suits are tried in open court and more quickly disposed of in consequence. In Germany every patent is absolutely valid after five years, and during the five years practically valid unless a proceeding is brought during this period in the Patent Office to vacate the patent.

Of course, neither in Great Britain nor in Germany are there nine courts of last resort and of co-ordinate jurisdiction. The necessity for establishing one tribunal of last resort, be it a special Court of Appeals or be it again the United States Supreme Court, seems "so self-evident that no man of ordinary intelligence can doubt it."

By united action inventors could do more to bring about the needed changes than by waiting for someone else to do the work.

* * *

Dr. B. C. Hesse, consulting chemist, of New York City, then made "some suggestions as to desirable improvements." He expressed the opinion that an inventor who allows his invention to lie idle, transgresses the spirit underlying the patent system. He is reserving for himself a field of endeavor which he has agreed to exploit and is not exploiting, and by his reservation he prevents its exploitation by others and thus retards progress.

A partial remedy for this might be a low annual tax, say, $15 or $25, or some other sum, not high enough to stand in the way of any invention giving any reasonable promise of remuneration, yet high enough to make it appear unprofitable to many to retain reservation in fields which they are either unwilling, unable or incompetent to develop.

It would be very wrong to believe that a patent when granted is valid to such an extent that any one contesting the legality of such reservation should be compelled to remain out of the field until he proves the contrary. Experience has led the courts to adopt a different view and in the majority of cases a patentee has to commend for the legality of his reservation, sometimes, if not generally, expending the greatest part of his energy in a litigated case in proving his title.

The reason for this seems to be that the courts have come to the conclusion that our system of preliminary examination does not properly safeguard the interests of the public. The remedy would, therefore, lie in the direction of improving or elaborating our system of preliminary examination, because an absolute abandonment of preliminary examination would be necessarily vicious.

The remedy which Dr. Hesse suggests is that after an application has been passed to allowance in the Patent Office the public, or so much of it as is interested, be given access to the disclosure of the invention and a reasonable time within which to oppose the final grant of the monopoly, as is done in Germany. A patent obtained under this mode to be given the right of preliminary injunction in its favor and all infringement or alleged infringement thereof to cease or to be prohibited pending final adjudication of the validity of the grant.

By this means the inventor, on the one hand, would receive a patent effectively shutting off infringement and consequent interference in his granted monopoly until his opponents have properly proven the illegality of the patent. The public, on the other hand, would be spared the issue of a very considerable number of patents presumably invalid and by exercising its rights to oppose the grant of patents of doubtful validity would save to itself many opportunities of endeavor and development and the expense and annoyance of proving in court the invalidity of a granted patent, together with the annoyance and interference which an invalid patent is capable of producing.

It should be noted that it is not contemplated to take from the public the right to attack the legality of the grant of the patent, but that that right remains fully open to the public throughout the entire life of the patent, subject to the condition that the patentee's rights must be fully respected until he is proven to be in wrongful possession.

* * *

"The Inventor's Standpoint" was discussed by Dr. L. H. Baekeland, the distinguished chemical inventor of Yonkers, N. Y. He emphasized that the patent laws of the United States have been conceived with an unparalleled spirit of liberality toward the inventor. The cost is small, the period of protection is long, more so than in other countries.

The patent examiners of the United States Patent Office are "able, earnest and fair," but they are "an underpaid, ill-recognized, unrewarded set of fine men." The attitude which the examiner takes in a case where things are not very clear is that of a representative of the average uninitiated public, and may be summed up in slang: "I am from Missouri," so that it becomes the task of the inventor of "showing" and "showing why."

In his own experience, Dr. Baekeland said, he had been thankful to the examiner several times for the objections made to text or claims, because the text was thereby shown to be not sufficiently explicit or concise, and by making the required amendments much future trouble was avoided in the eventuality of an infringement.

Dr. Baekeland thought he could hardly propose an improvement in the United States patent law without curtailing the privileges and interests of the poor inventor. But he suggested an act of reciprocity which would consist in exacting compulsory working of all patents taken here by non-citizens of the United States and whose countries have patent laws with a clause for compulsory working, which means great hardship for the American inventors who take our patents abroad.

The second part of Dr. Baekeland's paper dealt with the troubles experienced when it comes to testing the rights of the inventor before the courts. "Here the poor inventor is entirely at the mercy of the legalized system of piracy as carried out by infringers, helped by all the tricks of lawyers, and, let me say to the shame of our own profession, helped very often by experts who will back the lawyer to confuse an issue before a judge who most of the time is already incompetent in the art." Dr. Baekeland spoke of rich companies he knows in the United States whose main method of procedure is to frighten, bulldoze and ruin financially the unfortunate inventor who happens to have a patent which he is not willing to concede to them on their own terms; that is to say, for next to nothing.

Dr. Baekeland said he could cite several examples of prosperous companies where the money paid in salaries for the technical or scientific staff and for royalties is a mere bagatelle

if compared to the fortunes paid annually to the lawyers who happen to look after the patent litigation.

"The sooner we have a special and adequate patent court to which all patent litigation can be referred and which can operate without the absurd delays and abominable expenses now involved in patent suits, the sooner will cease this arrogant frustration of the generous efforts of those who framed our patent laws."

* * *

Dr. Hugo Schweitzer spoke briefly on some points raised by the various speakers. He also emphasized the importance of product patents for chemists.

Finally, attention was called to a bill now before Congress by which a final court would be created for the United States to which appeals in patent cases from the various District Courts would be made. (Concerning this bill, see the letter of Dr. Baekeland on page 56 of this issue.)

The Detinning Industry.

The Goldschmidt Detinning Company has been incorporated with a capital of $3,000,000 ($1,000,000 preferred and $2,000,000 common stock). The officers of the company are: Mr. W. T. Graham, president; Dr. F. H. Hirschland, vice-president and general manager; Mr. H. E. Rogers, secretary, and Mr. R. H. Ismon, treasurer. (Mr. Graham and Mr. Ismon are president and secretary respectively of the American Can Co.)

The company will operate under the patents of Dr. Karl Goldschmidt for the detinning of tin scrap by means of chlorine. The first works will be erected near Carteret, N. J., where the company has bought ten acres of land with waterfront. This plant will have a capacity of treating 30,000 tons of tin scrap per year and will start operation about October, 1909.

A second works is planned for the West.

The Goldschmidt chlorine detinning process to be used in these plants is already in commercial operation at the works of Theodor Goldschmidt in Essen. There it has supplanted the older electrolytic detinning process of Dr. Hans Goldschmidt, who is also the inventor of the well-known thermit process. The two brothers, Karl and Hans Goldschmidt, are

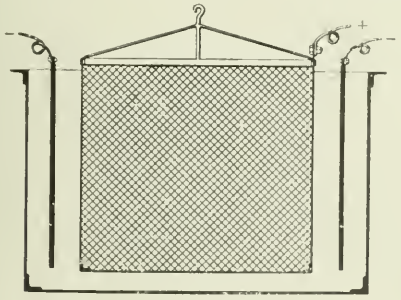


FIG. 1.—ELECTROLYTIC DETINNING CELL.

the owners of the tin and chemical works of Theodor Goldschmidt.

The Goldschmidt chlorine detinning process is also in commercial operation at the works of Gillet Fils in Lyons, France, one of the largest silk factories of the world.

The new works of the Goldschmidt Detinning Company will have their own liquid chlorine plant. The chlorine gas is to be furnished from the Wyandotte Works of the Pennsylvania Salt Mfg. Co.

This will be the first time that liquid chlorine will become commercially available in this country and enter into competition with bleaching powder.

It will also be for the first time that anhydrous tetrachloride of tin will be manufactured commercially in this country, though it has already been imported lately into this country by the Consolidated Color & Chemical Company of New York City from the Essen Works of Theodor Goldschmidt.

While the electrolytic detinning process has been kept a secret process, the chlorine detinning process is protected by patents. The important ones in this respect have all been noticed formerly in our columns, but a review of the whole present situation, covering both the electrolytic and chlorine detinning processes, should be particularly welcome at the present moment.

Such a review has been given by Dr. Karl Goldschmidt before the general meeting of the Verein Deutscher Eisenhüttenleute in December. In view of the authoritative character of this paper we reproduce it below in full, as far as it deals with the engineering problems of detinning. Only those parts which deal especially with German conditions are omitted. The full German text of the paper may be found in *Stahl und Eisen* of December 30.

Electrolytic Detinning.

As early as 1876 Keith (U. S. Patent 176,658) recommended to treat tin scrap by electrolysis in an alkaline solution. The firm of Theodor Goldschmidt began their work in this line in

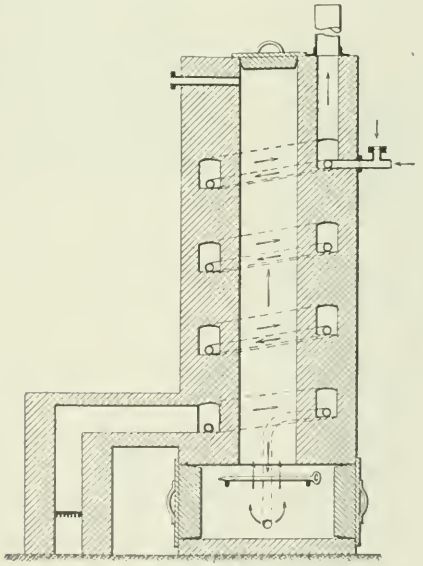


FIG. 2.—LAMBOTTE DETINNING FURNACE.

1882, using the tin scrap as anode and iron plates as cathode in an artificially heated solution of caustic soda. This idea is the foundation of the electrolytic detinning industry. But while the laboratory experiment is simple, the conditions in practice are difficult.

If we describe the reaction in an old-fashioned simple way, leaving the modern ionic theory out of consideration, we may say that the electric current decomposes the water and gives oxygen at the anode, forming tin oxide which dissolves in the excess of caustic soda to form sodium stannate, while hydrogen is developed at the cathode and at once precipitates the tin on the cathode from the solution.

The presence of free caustic soda is, therefore, a fundamental requirement. But caustic soda continually attracts carbonic acid from the air, forming sodium carbonate. Further, more tin is dissolved from the anode than deposited on the cath-

[illegible] the much greater surface of the former com[illegible] the latter. The free caustic soda has, therefore, a [illegible] to disappear and the electrolyte then becomes in[illegible] It is thus of fundamental importance to maintain [illegible] a certain excess of free caustic soda.

If the [illegible] becomes too small, the detinning is not perfect and not only is the tin output reduced, but the quality of the [illegible] is bad, as it contains too much tin for use in open-hearth works.

In the devices for artificially heating the cells care must be taken to prevent short-circuits, which would reduce the efficiency.

The tin scrap is always placed in a basket connected to the positive pole, as shown in Fig. 1. The construction of this basket involves difficulties. It must be of moderate size, since otherwise the tin scrap in the center would not be detinned. Further, the tin scrap is rather voluminous and cannot be used in compressed form, since the electrolyte should have free access to all surfaces. This means a small weight of tin scrap (only 10 to 20 kg.) per basket, and, therefore, considerable expense for wages.

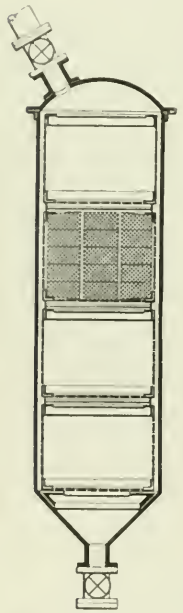


Fig. 3.—Chlorine Detinning Apparatus.

Only by very careful working and by giving continual attention to the right composition of the electrolyte it is possible to remove the tin so perfectly from the sheet iron that the latter can be sold to open-hearth plants. Even with very careful working, there will remain 0.1 to 0.2 per cent of tin on the iron, often more, like 0.3 to 0.5 per cent. Anyway, the iron is suitable for open-hearth practice.

The tin is obtained on the cathode in form of a spongy deposit. This may be easily removed and remelted, to get it in salable form.

The weak points of the process are the necessity of careful attendance and of small units (which means high wages) and a considerable loss of tin. This loss of tin is due to the fact that when the detinned iron is taken from the cells, a considerable quantity of the electrolyte which is rich in tin adheres to the surface. As the surface of tin scrap, treated per day in the Goldschmidt works, in Essen, covers an area of not less than 20 Prussian morgens (= 12½ acres), the quantity of electrolyte lost daily is quite considerable, even if only a small amount of tin electrolyte adheres to the surface. By washing with water a tin-containing precipitate of very little value is obtained.

The solid tin obtained by remelting the spongy cathodic tin is 97 to 98 per cent pure; some additions of lead cannot be avoided even if great care is taken.

Chlorine Detinning.

While 25 years ago the electrolytic detinning industry became possible with the advent of electric current supply on a commercial scale, the chlorine-detinning industry is the result of the availability of cheap electrolytic chlorine and the possibility of liquefying it.

In the middle of the last century Higgins (English patent 706, 1854), later Parmela (United States patent 102,148, 1870), Seeley (United States patent 127,375, 1872), and Panton (United States patent 135,578, 1873), attempted to detin tin scrap with chlorine.

It was early recognized that dry chlorine gas was necessary. Dry chlorine gas combines with tin with evolution of considerable heat, forming anhydrous tin tetrachloride, which is a heavy fuming liquid, already known to Libavius in 1605.

If dry chlorine gas is carried over and through tin scrap, the chlorine and tin combine, forming tin tetrachloride, which drops off. Dry chlorine does not attack the iron. The process is, therefore, very simple, but it took some 50 years to reduce it to commercial practice.

The difficulties were manifold. Firstly, methods had to be developed to cheaply produce and ship chlorine. Further, after treatment with chlorine, the surfaces of the scrap are covered with a film of a fuming and very obnoxious fluid which has a very bad effect on eyes and nose of the attendants. To remove this film was absolutely necessary; but the use of water for washing was impossible since a solution of tetrachloride attacks the iron so that both the iron and the tetrachloride become useless for commercial applications.

Even if the anhydrous tetrachloride is removed, the iron will quickly rust so as not to have any commercial value.

The first who carried out detinning by means of chlorine was Lambotte, who built a larger plant in Brussels, in the eighties, the arrangement being shown in Fig. 2. It is a shaft furnace through which the tin scrap is carried downward from above, while chlorine gas, diluted with air, is introduced at the bottom (German patent 32,517, 1884).

The chlorine combines with the tin and the air carries the tetrachloride of tin into a condensing apparatus. The detinned iron-scrap bundles are removed from the bottom of the furnace.

The chief difficulty of this process was that the iron scrap was exceedingly liable to rust, as with all former processes of detinning with chlorine. Even if all moisture was carefully avoided, and the resulting steel-gray iron was stored in a very dry place, it would rust and the corrosion would continue to proceed very quickly. The reason of the corrosion was found in the fact that the chlorine is not absolutely without any attack on the iron, but forms a very thin invisible film of anhydrous ferric chloride on the surface of iron. If the iron is exposed to air the anhydrous ferric chloride will attract water from the air and rusting would result. The ferric chloride is reduced to ferrous chloride and this attracts again oxygen and water from the air, forming oxychloride; this is again reduced by the iron, forming rust, and so on. Only when this fact had been found the corrosion of the iron was prevented by removing the ferric chloride film by a washing process (German patent 176,457, see our Vol. IV, page 501).

The tin scrap must be dry and free from all organic substances, paper, lacquer, etc. It is necessary to remove not only any adhering moisture, but anything that can form water. Tin tetrachloride is a substance which attracts water with great avidity and carburizes organic substances. Every chlorine detinning apparatus should therefore be marked: Extra Dry.

The tin scrap is compressed into bundles (in which form they are later sold to the open-hearth steel works) and placed into cylinders, which are then closed. (Fig. 3.) Chlorine gas is then introduced. It is important to prevent an undue rise of temperature (German patent 188,018). As tin and chlorine when combining to tin tetrachlorine develop considerable heat, artificial cooling must be provided.

To detin the scrap completely it is necessary to use the chlorine at a pressure of several atmospheres so that it enters all crevices. When the gaseous chlorine forms liquid tin tetrachloride, the pressure is reduced. As long as the pressure continues to drop, detinning takes place. When the pressure remains constant for some time, it is evident that the chlorine does not find any more tin to combine with. This is a sure indication that the detinning operation is completed.

The chlorine and tin tetrachloride are removed, the iron scrap bundles are carefully washed, and are then ready for delivery to the open-hearth steel works.

The chief advantage of the chlorine detinning process over the electrolytic process is that there is very little expense for

attendance, as the scrap is passed in large bundles through the process. The process is completed in one single operation. The tin tetrachloride is a valuable product for its use in silk mills.

FIG. 4.—GOLDSCHMIDT TIN AND CHEMICAL WORKS IN ESSEN.

The iron is detinned by this process more completely than by the electrolytic process. No tin is lost in washing.

With respect to the analysis of detinned iron, chemists are liable to make the mistake of using too small quantities. By analyzing 10 grams it is quite possible to find no tin, while the iron surfaces may contain considerable tin at other points. To get a good average sample, the practice in the Goldschmidt works is to dissolve always 3 kg in hydrochloric acid; the result is considered satisfactory only if the analysis gives considerably less than 0.1 per cent tin.

Detinning of Old Cans.

Formerly only the scrap from the tin-can factories was detinned. This was a very pure starting material for the detinning process. But with the growth of the detinning industry, the demand for such tin scrap has become greater than the supply, and while such scrap could be had for nothing 20 years ago, it is now rather expensive.

Naturally many attempts have been made to make the enormous supply of old, used tin cans available for detinning. But this has great difficulties. There are not only the impurities from the former contents of the cans (eatables, etc.), but also the paper labels, the solder containing lead, and the thin rubber ring which in folding the edges of the tins is placed in the fold to make it tight. Further, the cans are very voluminous.

The cans are first compressed and, by means of rolls with sharp cutting points, they are provided with a great many holes and cuts. Any adhering fat, lacquer, etc., is then removed by washing in caustic soda solution. The cans are then washed in pure water, and the solder and rubber rings are removed by heat in a furnace. The tin cans are now pure iron and tin and are compressed into bundles for detinning.

Tin cans which have not been cleaned in this way yield little tin in the detinning process, while the iron is of inferior quality.

The tin scrap is obtained from the tin can factories in all parts of the world and shipped to the detinning works: from Italy (sardine boxes), from Egypt (cigarette boxes), from Newfoundland (lobsters), from Norway (fish conserves), from Switzerland (condensed milk), etc. To detin the scrap right at these places would not pay, because the quantity of available scrap would be generally insufficient; further, the detinned iron would have to be shipped anyway to the steel works, and it weighs almost as much as the scrap.

The detinning industry of Germany treats per year about 75,000 tons of scrap. Of these, 50,000 tons are detinned in the Goldschmidt works, in Essen, and the balance of 25,000 tons in 8 or 10 smaller works. Small works are, however, hardly economical and their troubles are increasing.

In other European countries somewhat over 25,000 tons of tin scrap are detinned per year; in the United States about 60,000 tons. The total for the world is, therefore, 160,000 tons scrap, yielding 3000 to 3500 tons of tin, which is 3½ per cent of the total yearly output of tin. When the treatment of old tin cans will assume greater proportions, the output of the detinning works will, of course, greatly increase.

The weight of the detinned iron is about the same as that of the tin scrap, that is, about 75,000 tons of iron per year in Germany. The detinning industry is, therefore, not so absolutely unimportant for the steel industry; one may remember the old farmer's saying: "Kleinvieh macht auch Mist."

Notes on Electrochemistry and Metallurgy in Great Britain.

(From our Special Correspondent.)

The Physical Society's Annual Exhibition of Apparatus.

The fourth annual exhibition of electrical, optical and other physical apparatus was held at the Royal College of Science, South Kensington, on Dec 11, 1908. Invitations were extended to members of kindred institutions, and there was a good attendance to view a decidedly interesting collection of exhibits which fully maintained the standards of previous years.

The Cambridge Scientific Instrument Co., Ltd., showed their vibrating tongue extensometer, said to detect an extension of one part in a million without mirrors or microscope. Callendar & Barnes' continuous flow calorimeter; Meker burners and furnaces—the latter being capable of melting platinum with an air blast; the Fery radiation pyrometer, and Joly's meldometer for determining melting points of minerals, etc., with very small samples.

Messrs C F Cassella & Co. gave practical demonstrations with Capt Sankey's new machine for rapidly testing steel and other metals. The test occupies about one minute; and an automatically plotted record gives the number of bends, bending effort in foot-pounds, and total energy required to break the test piece.

Among the exhibits of Messrs A. C. Cossor, Ltd., was the "Rose" vacuum pump for rapidly producing very high vacua. The piston is operated by an electromagnet; there is not any

mechanical connection through the cylinder to the piston, and so leakage is impossible.

Messrs. Elliott Bros. had, among their several instruments, a moving-coil leakage indicator, a portable alternating-current standard wattmeter, and also their "reflectroscope" for projection of opaque objects in natural colors. In this apparatus the rays are parallel, and delicate specimens may be exhibited without injury by heat.

Messrs. Everett, Edgcumbe Co.'s high- and extra-high-tension (Jona pattern) electrostatic voltmeters present new and distinguishing features. The instrument shown had a double range, from 12,000 to 60,000 volts. A self-contained portable potentiometer designed for checking ammeters, voltmeters, wattmeters and for photometer work, deserve special notice.

A notable feature of Messrs. A. Gallenkamp's apparatus was a cheap electric tube-furnace, having no platinum in its construction, for temperatures up to 1000° C.

Messrs. J. J. Griffin & Son had several types of electric furnaces, including one in which only one-sixth of the platinum ordinarily required was employed in the form of strips of foil. Their quartz-glass amalgam lamp, giving a strong ultraviolet spectrum, attracted considerable attention. They also showed platinum resistance thermometers with quartz insulation and mounted in quartz-glass tubes, the resistance wires being completely protected from the action of gases.

Messrs. A. Hilger's exhibit was most interesting, and included their wave-length spectroscope, reading direct on a spiral drum; an echelon spectroscope and 20-plate echelon grating, and a large quartz spectroscope giving a spectrum 200 mm in length.

Mr. Hans Knudsen showed his ingenious apparatus for wireless transmission of photographs.

Marconi's Wireless Telegraph Co. had on view a new multiple tuner for wireless receivers, which is said to secure a high degree of immunity from interference.

Messrs. Nalder Bros. and Thompson's telethermometer is a new instrument which indicates temperature electrically with rapidity and great accuracy.

Mr. Robert W. Paul had a good assortment of electrical instruments, and showed Irwin's hot-wire oscillograph at work recording alternating-current wave-forms. A special form of camera takes photographic records.

Messrs. Pitkin & Co. exhibited their latest laboratory and workshop types of Holden-D'Arsonval galvanometer, and the Roberts-Austen recording pyrometer now used at Woolwich Arsenal, which enables the temperature to be observed externally at any moment without interference with the record.

Messrs. Siemens Bros. & Co. had an attractive exhibit from which we select for mention their apparatus for rectifying alternating currents of 100 to 600 volts; a portable current transformer for accurate laboratory work, in which the ratio is constant from 10 per cent up to 100 per cent of rated load; dynamometer-principle ammeters and wattmeters and a testing magnetizing apparatus.

Messrs. Snell & Tinsley's leading items were Drysdale's standard wattmeter, giving accurate readings on the lowest available power factor, and a Tinsley direct-reading potentiometer designed for work with from 1.8 to 2.2 volts, between which limits adjustment to 0.0001 volt can be made without additional rheostats.

Messrs. Strange & Graham's apparatus for making metal ribbons was shown working. The molten metal flows from a suitable orifice onto the periphery of a rotating, water-cooled drum. Solidification is apparently instantaneous, and the metal is thrown to a distance of several feet in a continuous ribbon surprisingly uniform in thickness and width.

Messrs. Carl Zeiss's demonstration of their projection apparatus for fluid crystals was much admired. The apparatus consists of an optical bench with an automatic-feeding 20-amp arc lamp, and provided with an excellent combination for microscopic projection from cells in which the formation and liquefaction of various crystals are brought about by carefully arranged heating apparatus fitted to the sub-stage and a cooling apparatus above the mechanical stage. The polarizer and analyzer of the microscope are specially constructed, and the body tube is of large diameter to permit low- and high-power work without diminution of the field.

Faraday Society.

The following papers were read at the meeting of Dec. 15: "The Redetermination of the Electrolytic Potentials of Silver and Thallium," by Dr. F. J. Brislee; "The Heats of Combustion of Aluminium, Calcium and Magnesium," by F. E. Weston and H. R. Ellis; "The Formation of Graphite by the Interaction of Magnesium Powder and Carbonates," by H. R. Ellis, and "Colloidal Barium Sulphate," by Dr. E. Feilmann.

With respect to Dr. Brislee's paper on the electrolytic potentials of silver and thallium, Dr. Abegg (Breslau), in a communication, pointed out that Dr. Cumming had already found, and published in the *Transactions* of the Faraday Society, that ammonium nitrate solutions are not applicable for eliminating liquid potential between basic solutions. He expressed the hope that the symbols proposed by the Bunsen-Gesellschaft in 1903, and accepted by the fifth international congress of applied chemistry, at Berlin, the same year, might be adopted in Great Britain.

Dr. G. Senter inquired whether the variations in the results obtained by the author would not be accounted for by slight differences in temperature.

The chairman, with reference to Dr. Senter's question, said he was of opinion that some methods, such as those employed by the author, were attended by an appearance of accuracy which was rather fictitious and which the experimental results did not justify.

In the discussion on Messrs. Weston and Ellis's paper, a communication by Dr. Borns pointed out that, although Mr. Weston had said that he was repeating his experiments *in vacuo*, such experiments as those detailed by the authors could not render reliable results as to the uncertain heats of formation of the oxides of aluminium, calcium and magnesium. Mr. Weston was working in air, and powdered his metals; the mixtures presumably stood for hours, and it was doubtful whether the metals were free from oxide when the experiments were started. Shavings of electrolytic calcium, turned on a lathe, could hardly be free from oxide.

H. K. Picard said that while assisting M. Vautin in his early experiments on what is now known as the "thermit" process, he had carried out a large number of reductions of oxides and sulphides by aluminium, and had arrived at the same conclusions as the authors. The study of the reaction between alumina and aluminium sulphate would be interesting. He had not succeeded in bringing it about, but saw no reason why it should not be effected, although it was always impeded by formation of aluminium suboxide. As a possible method of manufacturing aluminium, he commended it to the authors for an experimental investigation.

Dr. N. T. M. Wilsmore was in agreement with the view that the reactions were too complicated to warrant deductions from the heats of formation of simple oxides. In answer to Dr. Borns, he thought metallic calcium was nearly as stable as magnesium.

Mr. H. R. Ellis replied that the nitride formed when magnesium was employed in the reductions was evidently not magnesium nitride. When magnesium is burned in air, or when it reduces an oxide of a metal which does not form a nitride, only a very small amount of nitride is produced; and as magnesium nitride readily burns to oxide when heated, the great evolution of heat attending the combustion would destroy any nitride when magnesium is burned in air or when the powdered metal reduces an oxide which has a small heat formation. The reduction of copper oxide by Mg evolves 111,000 calories, but that of calcium oxide only 3000 calories. In the latter case formation of magnesium nitride might be expected; but, al-

though an excess of Mg increases the quantity of nitride, it is never greater than the calcium accounts for, and, moreover, strontium and barium oxides, with a much higher evolution of heat, give a greater yield of nitride, while silica and boron-trioxide are reduced by Mg with a very small yield of nitride and only a moderate evolution of heat—20,000 calories and 42,000 calories, respectively.

On Mr. H. R. Ellis' paper, Dr. Borns remarked, in a communication, that the author's results were of very great interest. The combustions were started by magnesium, and in such cases ammonia might be formed from magnesium nitride. It was well known that carbide and nitrogen alone would yield hardly any cyanamide, and the presence of some other substance was necessary to render the process remunerative. Some investigators had recommended the use of calcium carbonate for this purpose.

With respect to Dr. Feilmann's paper on "Colloidal Barium Sulphate," Dr. V. H. Veley (communicated) remarked that from the description of the liquids as having "the appearance of ordinary milk, by reflected light," it seemed that they were of the nature of emulsions, and their general properties are similar to those described by Pickering in *Trans. Chem. Soc.*, 1907, 2001. A fuller examination into the dimensions of the particles of barium sulphate was desirable. He had ascertained the size of particles of barium sulphate precipitated from the chloride by a sulphate without free acid—which gives a more crystalline and coarser-grained precipitate—and found the average diameter was 0.001 mm to 0.002 mm. The edges were sharp and well defined. Particles of the collodial sulphate would probably be larger and without definite edges. With a microscope of high power and a hot stage, the temperature of transition from the colloidal to the crystalline condition could be ascertained by slowly melting off the organic menstruum. The conditions of precipitation by acids and re-solution by alkalies could be studied, and more information obtained as to the sizes of the particles according to the nature and concentration of the acid or alkali. It appeared possible that by repeating the experiments of Lodge (Brit. Asso. *Report*, 1884, 309), varying the conditions of diameter of tube, potential and current, every variety from well-defined cystals to amorphous masses could be obtained.

Professor Haldane Gee (communicated) observed that since the work of Graham, in 1861, colloidal chemistry has been much extended in its scope, and promises to become a very important branch of physical chemistry and fertile in technical applications. The action of organic colloids in producing stable colloidal solutions has not been completely explained. That the particles seem to be coated by the protector is in accordance with the fact—shown by Quincke—that given three immissible liquids, *A*, *B* and *C*, then *B* will tend to form a layer separating the others if the sum of the surface tensions between *A* and *B* + *B* and *C* is less than the surface tension between *A* and *C*. It had been suggested that the coating may form a permanent electric "double layer" preventing the neutralization of the nucleus by ions of an opposite charge. The extension of the author's method to calcium salts would be interesting. Using albumen and like substances much might be learned of the method of production of dentine and other hard substances in the animal tissues.

Dr. G. Senter understood the author to mean that the barium sulphate was not truly in a colloidal state, but in crystalline particles surrounded by casein. That was not in agreement with Dr. Veley's views. Could the question be settled by vigorous scrubbing of the particles with sand, and observing if a colloidal solution would still be formed? He suggested examination with the ultra-microscope, and also the employment of a smaller proportion of casein.

Dr. Borns, with reference to the point raised by Dr. Senter, stated that other investigations dissolve barium oxide in aqueous methyl alcohol, pass CO_2 through the solution, and obtain a gelatinous solution perfectly soluble in water so long as any methyl alcohol remains, and forming colloidal barium sulphate with sulphuric acid. Here there was not any colloidal envelope for the particles. He suggested the employment of colloidal barium sulphate for coating the interior of the copper globe of a certain street photometer, recently exhibited in London, instead of the ordinary sulphate.

Market Report for December.

Tin has fallen considerably, from £134 10 0 on the 1st to £131 on Dec. 7th, rose again to £132 on the 10th, and had a sharp drop to £130 10 0 by the 14th. Since recovered to £131.

Copper has been fairly steady in the neighborhood of £62 during the month, with sharp rise from £62 5 0 on the 5th to £64 on the 10th. Now at £63 10 0.

Pig Iron (*Cleveland*) has risen slightly from the original quotations; dropped slowly to 48/- during the month, but recovered to 49/3.

Scotch Pig has been down to 54/-, but recovered to original quotation, 55/6.

Hematite dropped from 58/- to 57/6.

Lead stead at £13 10 0.

Other prices were as follows during December:

Antimony, Star Regulus, per ton	£32	0	0 to £34 0 0
Ammonia Sulphate, f. o. b. Liverpool, per ton			24 0 0
Copper Sulphate, per ton			20 10 0
Bleaching Powder, 35 per cent, per ton			4 5 0
White Caustic Soda, 77 per cent, per ton			11 2 6
Carbolic Acid Liquid, 97/99 per cent, per gal.			1 0
Creosote, ordinary good liquid, per gal.			2¾
Naphtha Solvent, 90 per cent at 160 deg. C., f. o. b., per gal.			11¼
Pitch, f. a. s. Manchester, per ton			18 0
Shellac, Standard T. N. Orange spots, per cwt.			4 10 0
Benzole, 50/90 per cent, per gal.			6
Rubber, Para fine, per lb.			5 1

SYNOPSIS OF PERIODICAL LITERATURE.

Iron and Steel.

Blast Furnace Explosions.—The great loss of property and life accompanying the explosions which sometimes follow a slip in the blast furnace has made these accidents the center of a great amount of study. In *Stahl u. Eisen* for July 15, W. Van Vloten communicated an article on the cause of these explosions and recently in the December 2 number of the same journal further correspondence appears on the same subject by Teichgraber and Osann. Van Vloten's original conclusion as to the cause of these explosions was in the fact that following a slip an intimate mixture of fine ore and coke was suddenly dropped into a hot zone, with the resulting formation, if both coke and ore were hot, of a large volume of CO according to the usual reaction of reduction. The high temperature of the region in which this gas was formed also greatly increased its normal volume. The explosions cannot be conceived to have been produced by the agency of air, as air cannot be introduced into the region in which they apparently take place. In support of this theory the author took a large diameter iron tube, inside of which he placed at one end two shorter and smaller diameter tubes filled with ore, the space around the smaller tubes being filled with coke dust. The whole was heated to redness and suddenly inverted, mixing the red-hot ore and coke in the end of the large tube. On this mixing of the ore and coke a manometer on the large tube suddenly recorded a pressure of four atmospheres. No explanation is given of the reason why explosions are more frequent when charging is done too much in the middle of the furnace, though this is recognized as a source of danger. Teichgraber offers a simpler explanation. An arch is formed of the stock in the furnace, this arch permitting of the formation of a hollow space underneath. The arch collapses and forms a second hollow space above the former. In the formation of this second hollow space air is pulled in from the top and mixes with gas in this hollow and causes the explosion. The remedy is to keep the top of the furnace closed or else introduce gas there from another furnace when the explosion is about to occur; in other words, until a slip is likely to take place. Osann does not believe that it is possible for the reaction Van Vloten quotes to take place so rapidly as to cause the great increase in

pressure given because it is an endothermic one, and end other [illegible] reactions cannot be explosive in character. He claims the explosion is not a true explosion, but merely an expulsion of a large quantity of gas which carries with it some of the stock, the explosion being due to the arching of the charge with the formation of a hollow underneath the arch. On the collapse of the arch this gas in the hollow space is expelled from the furnace.

Van Vloten ridicules both explanations on the grounds: The explosion takes place when the top of the furnace is closed and no air can be sucked in; again, even when an arch falls into a hollow space, the total volume of the furnace stack is constant and the amount of material in it is the same, therefore without gas generation or some other cause of sudden increase in volume there should be no explosion. In case of the reaction being endothermic, the residual or sensible heat in the ore and coke is quite sufficient to cause it to take place.

Styrian Steels.—The careful methods used in the manufacture of the high-grade Styrian steels have recently been described in *Stahl und Eisen* and later translated into *Iron Age*, this abstract having been taken from the former journal. This district is one of the richest in Europe in iron ores. They were mined here and iron was produced in the early Roman period, the methods in vogue still being many years behind modern practice, but the Styrian iron masters are loath to give up their proven methods for more modern ones until they are assured of the same high quality of product. The Kappenberg works, the most famous of them all, were founded in 1446, though at present a modern electrical equipment in the shape of handling appliances, annealing and melting furnaces is being installed. The graphite crucibles used in melting the steel are used only once, it having been found that the reactions produced by the crucibles are not the same the second melting as the first and so to use them a second time would be to sacrifice the one quality of product they pride themselves on—uniformity. These crucibles are made on the premises, the graphite used in them analyzing C 77.80, SiO_2 13.04, Al_2O_3 6.12, Fe_2O_3 0.44, P_2O_5 0.01, K_2O 0.43, H_2O 1.05. The crucibles are in the drying house six to seven weeks. The ore used in the blast furnace analyzes Fe 38.9 per cent, Mn 2.1, P 0.17, S and Cu traces. The blast furnaces are 40 ft. to 50 ft. high and in outward appearance resemble medieval castles. In making white iron 1300 lb. and in making gray iron 1500 lb. of charcoal are used per ton of iron. The pig iron is converted into steel in a charcoal finery, taking for this operation as many days as the puddle furnace hours or the Bessemer converter minutes. This furnace consists of a shallow pit lined on four sides with iron plates, above one there being placed a slanting tuyere. The pit is filled with charcoal and on this is placed the iron to be melted down. In refining gray iron, three meltings are required, the first taking out the silicon and most of the manganese with a small portion of the carbon. The second melting takes out more of the carbon, the third step completing the removal of the carbon. White iron requires one less melting. If steel is to be made, one less melting is required. The soft iron made in this way does not contain, excepting the carbon, more than 0.09 per cent foreign elements, of which more than half is usually manganese. Only 40 to 50 crucibles are melted at one time in a furnace to insure all having exactly the same temperature. The crucibles are preheated in two forewarmers at 400° and 800° for four hours each before entering the melting furnace. All ingots are hammer forged.

Steel Pipe.—Last year there was a million and a half tons of welded pipe produced in this country, 80 per cent of which was of steel. This pipe is being used for all sorts of purposes, its merits for water and gas mains being discussed in a paper read at the October meeting of the American Gas Institute by Mr. F. W. Speller. Steel pipe is about twice as strong as iron pipe and shows the same proportionate resistivity to alternate stresses. It is necessary to pay much greater attention to the threading of steel pipe, its greater hardness requiring a different form of die. If the pipe is to be gas-tight when screwed together dry. Considerable attention to the corrosion of the two kinds of pipe was given, with the conclusion from the work of Howe and others that steel pipe is at least no more subject to corrosion than iron pipe and in many cases stands up better.

Cupola.—At the Toronto meeting of the American Foundrymen's Association an interesting discussion arose on the merits of the Balliot cupola. The main feature of this cupola are the use of a double row of tuyeres, even supplemented by a third row at some distance from the others so as to ensure as complete combustion as possible, and the return of a part of the gases from the top of the cupola to the zone of combustions. These returned gases to be effective should be as rich in steam and carbon dioxide as possible. The return of this waste gas prevents too high a temperature in the usual low zone of combustion and extends this zone to a considerable distance up the stack by the use of the multiple rows of tuyeres. A ring at the top of the stack allows of the preheating of some of the air used, also leading to economy. More data is required on the actual behavior of this cupola in practice before criticizing or condemning it.

Iron and Steel Institute.

PAPERS READ AT THE MIDDLESBOROUGH MEETING.

A Workshop Microscope.—J. E. Stead points out that for this purpose the microscope must be simple. Few parts are essential and rough handling is to be expected of such an instrument in the shop. The microscope described uses as source of light a low-voltage electric lamp fed from the shop circuit if available or from storage batteries in case such is not at hand. This lamp is placed in a tube joining the optical tube of the instrument at right angles. For low powers the light is reflected to the work by means of a mirror, the objective being above the source of light and its mirror. For high powers the light is reflected down through the objective by means of the ordinary plane-glass illuminator, and back through the optical tube of the instrument. The advantage of placing such an instrument in the hands of the shop foreman for examination of the surface of castings, semi-finished pieces, etc., is readily seen.

Metal Mixer and the Open-Hearth Furnace.—A. E. Pratt points out that the metal mixer is not only used to-day to ensure a certain uniformity in the metal charged into the open-hearth furnace, but has recently taken on the rôle of a partial refiner. Desulphurization by the use of manganese is commonly carried out in this apparatus. By maintaining a cover of basic slag in the mixer, especially if high in oxides of iron, a surprising elimination of impurities may be accomplished. Fluorspar is commonly added to ensure the fluidity of this slag. The author proposes the following modification of the open-hearth practice as a means of using this apparatus to its full advantage:

In the open-hearth process three periods are recognized in the reactions taking place: (1) A melting down of the pig if charged solid; (2) low-temperature portion of the operation in which the larger part of the metalloids are removed, but a small portion of the carbon being oxidized; (3) high-temperature portion of the operation in which the remainder of the carbon is removed with the rest of the metalloids. In ordinary practice it is true these three periods merge into one another, but they do so only at the expense of efficiency, for the metalloids are but poorly removed at high temperatures and carbon is but inefficiently removed at low temperatures. For ideal working each should take place at its own temperature of maximum efficiency independent of the other. The proposed method is really designed to do away with these transition periods. A large gas fired metal mixer called the "finer" is charged with raw metal and materials to make a covering of highly basic slag, this slag being removed from time to time as it becomes foul and replaced by fresh oxides. The temperature of this "finer" is run low, that at which the metalloids are removed at greatest efficiency. Carbon is not to be removed in this furnace.

A second furnace called the "scrapper," of similar design to the finer, but connected to a larger gas supply and capable of being run at a maximum temperature, is used to heat scrap to the highest possible temperature. These furnaces should be tilting furnaces, best of the Talbot type in which charging and tapping may be continuous. A third series of furnaces known as "finishers," similar to the ordinary type of open hearth furnace, are charged with metal from the scrapper and into which metal is run from the finer. The reaction which takes place on running this finer metal into the hot scrapper metal is most violent and carbon is practically instantaneously eliminated. It is advised to add preheated lime and oxides to the scrapper metal as it is poured into the finisher, or the same may be preheated in this last furnace and the scrapper metal run in on top. The bath is finished in the usual way.

Where large quantities of scrap are not available a modification of the process is recommended. A Talbot furnace is charged with finer metal and heats this charge to a high temperature. Oxides are added in small portions to remove the carbon from this high temperature metal and more finer metal and oxides charged. The advantages claimed for the process are continuity, increased yield, rapid working, a marketable finer slag to be used as fertilizer, low labor costs, uniform temperature in each furnace tending to long life of the same, high-grade output, insures a regular supply of metal to the mills, no furnace is kept waiting for metal, there is no large stock of dead soft metal locked up the process, a triplicate plant is not really necessary as all are working at the same time at their maximum efficiency.

Oval Blast Furnace at Newport.—The modern American blast furnace, with a 13-ft. diameter tuyere section, requires high-pressure blast to insure complete combustion to the middle of the section. High-pressure blast engines are expensive pieces of apparatus to install and run. For this reason a means was sought to obtain the output of such a furnace with a cheaper blowing equipment. It was desired to replace the 15-lb. blast pressure with one of six and to do this an oval cross-section of the furnace was determined on. The tuyere section of the furnace as built is 9 ft. x 17 ft. approximately, the section being oval to the top. The height of the furnace is about 80 ft. The furnace is claimed to be a success in every way, though but few details of its running were given.

Testing the Wearing Qualities of Steel Rails.—E. H. Saniter points out that for a long time the wearing quality of steel rails has been determined from the hardness of the rail, this property being usually determined by Brinell's method. A machine described in this paper is designed to determine this property from a test specimen. A cylindrical test piece is cut from the head of the rail, this test piece being chucked to a revolving shaft. A ring of hardened steel accurately fits this test piece, this ring in turn fitting into a bearing ring, a ball-bearing reducing friction between the hardened ring and the bearing ring. A load may be placed on the bearing ring, the hardened ring being carried around with the test piece by the friction between the test piece and the hardened ring. On revolving the test piece it suffers wear from this friction and the wearing qualities of the rail is represented by a factor, the number of ten thousandths of an inch in diameter worn down of the test piece in 200,000 revolutions. For instance, a nickel steel rail, 3.5 Ni, showed the factor 28, while ordinary carbon rails show factors between 45 and 65.

Copper.

Analysis for Copper Refineries.—The *Chemical Engineer* for October contains a scheme by Robert Kann for the complete works analysis of the electrolyte used in copper refining. In brief the methods used are as follows: Determination of copper: 10 cc of solution are diluted to 100 cc and the copper precipitated by boiling with sheet Al. Filter, dissolve the Cu in HNO_3, evaporate to remove NO, add tartaric acid, excess of ammonia and titrate with KCN. Iron: Oxidize 25 cc with HNO_3, boil, add ammonia, boil again, filter, wash, dissolve precipitate in HCl, pass in H_2S, filter, wash, oxidize filtrate, precipitate with ammonia, wash, ignite and weight as Fe_2O_3. It is better to determine with $KMnO_4$ if standard solution is prepared. Calcium: 25 cc should be made alkaline with ammonia and precipitated with ammonium oxalate. Boil, let settle, filter, wash with hot water and ignite in a porcelain crucible. Dissolve in HCl 1:1, add ammonia to precipitate iron, filter, wash, and again precipitate with ammonium oxalate. Filter, wash, dissolve in dilute H_2SO_4, add a drop of HCl, and titrate with $KMnO_4$. Nickel: To 25 cc of electrolyte add 10 cc strong HCl and 200 cc water. Precipitate with H_2S, filter, dissolve filtrate in HNO_3, evaporate to dryness, take up in 10 cc HCl and add 100 cc water. Precipitate with H_2S and filter, receiving filtrate in same beaker as at first. Add HNO_3 and evaporate to 200 cc. Precipitate the iron with ammonia, repeating the precipitation. Add acetic acid in slight excess, heat and precipitate with H_2S. Filter, wash, and ignite. Dissolve the precipitate in HNO_3, adding two drops H_2SO_4, evaporate carefully and weigh as $NiSO_4$. Arsenic: Take 10 cc and put in a 300 cc Jena flask, add 2 grams $FeSO_4$ and two small pieces of glass to prevent bumping. Fit the flask with a two-holed rubber cork through one of which passes a separating funnel and through the other a connection to a Liebig condenser. For heating the flask an electric hot plate is recommended. Run through the separating funnel 25 cc HCl, sp. gr. 1.20 and distill. Receive the distillate in a 500 cc beaker containing 20 cc water. Repeat distillation with 25 cc more acid. Neutralize the distillate with ammonia, make slightly acid with HCl, add sodium bicarbonate, cool, and titrate with a standard solution of I. Antimony: Add ammonia to 25 cc of the solution and precipitate with H_2S. Filter and wash. Add dilute H_2SO_4 to the filtrate to precipitate the sulpho-salts and let stand until clear in a warm place. Filter off the sulphides of arsenic and antimony through a small Hirsch funnel using asbestos. Transfer to a 200 cc beaker and add 20 cc HCl. Heat to just below boiling to remove H_2S. Cool and filter through asbestos, dilute to 200 cc, add tartaric acid, neutralize with ammonia, add HCl to acid reaction, then sodium bicarbonate and titrate with a standard solution of I. Bismuth: Precipitate 100 cc of electrolyte with ammonium carbonate, filter, wash, dissolve in dilute HCl, precipitate with H_2S, dissolve out the sulphides of antimony and arsenic with ammonium sulphide, filter, wash, dissolve in HNO_3, add ammonia and ammonium carbonate, filter, wash, dry and ignite and weigh as Bi_2O_3. Chlorine: Add nitric acid and silver nitrate to the electrolyte and filter out the silver chloride. Scorify the paper with test lead, cupel and weigh the silver. Total sulphuric acid is determined by acidifying with HCl and precipitating as BaSO.

Oxy-Acetylene Flame.

Welding and Cutting.—Cutting and welding by the use of the oxy-acetylene flame, which has been the subject of numerous articles in this journal, has recently been discussed in two papers, one read before the Technology Club, of Syracuse, by Eugene Bournonville, and published in *Iron Age*, November 26, the other an anonymous contribution to *Engineering News*, November 19. Three classes of burners are in use—high, medium and low pressure burners. The high-pressure burner requires both gases to be used under pressure, and suitable valves must be inserted in the supply pipes to prevent one gas from forcing itself over into the other's tank. The usual pressures used in this type of apparatus vary between 125 lb. and 200 lb. per square inch. They allow of an absolute control of the gas mixture, but there is difficulty in providing the gases under the high pressures, the tips are likely to get hot and burn off, and finally great skill is required in their manipulation to prevent the blowing away of the metal as fast as melted. Particular attention is called to the dangers of the gases under high pressure: one usually overlooked is the lubrication of the oxygen compressor, most ordinary varieties of oil vaporizing and forming an explosive mixture in the tank. The best burner suitable for general work uses the gases under medium pressure

8 l[illegible] 15 lb. per square inch. Such burners when provided with an extra jet for conveying oxygen at high pressure just back of the flame are used for cutting purposes, the flame heating up the metal to the ignition temperature and the oxygen from the extra jet burning it out. With such a burner a steel bar 2 in. x 2 in. was cut through in one minute; a 9 in. I-beam was cut through in two minutes, a 4-in. x 6-in. beam built up of two bars was cut through in six minutes after being brought to the starting temperature. The low-pressure burners require oxygen under pressure, the acetylene being drawn into the burner by an injector action. They lack control of the mixture. By the use of the oxy-acetylene torch it is possible to weld copper to iron and cast iron to steel, the weld in this latter case showing a gradual transition from the one metal to the other.

Zinc.

Bright Electrolytic Deposits.—A method of obtaining bright deposits of zinc by electroplating is described by Carl Richter in *Electrochem. Zeit.*, and noticed in Lond. *Elec. Eng'ing*, Dec. 31. The bath employed is a modification of that of Pfannhauser, and consists of zinc sulphate and ammonium sulphate, but, whereas that of Pfannhauser is employed neutral, Richter adds small quantities of sulphuric acid: the amount, however, is extremely small, varying from 1/38 to 1/20 normal. The temperature of the bath was usually kept at that of the atmosphere, a current density of about 80 amperes per square decimeter (about 740 amperes per square foot) was employed, the e.m.f. being between 0.75 and 0.85 volt. Electrolytic zincing has so much in its favor, at any rate for small articles, and for articles which require to be bent about, owing to the extremely adhesive condition of the zinc, that given a method for depositing it in a bright form, it should rapidly come into use on a large scale. One of the objections to hot galvanizing is the large amount of spelter which requires to be kept in use, and the deterioration which takes place by alloying with the articles which are dipped, and the necessity to keep the bath molten means the consumption of a large amount of fuel.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Electrode Construction for Furnaces.—Dr. P. L. T. Héroult has designed a stuffing box through which the electrode is fed into the furnace as its end burns away. The stuffing box is provided with a packing of conducting material through which the current is passed to the electrode. The packing is loose graphite in form of grains of varying sizes, so that the voids between the larger grains are filled by the smaller grains, and the entire mass makes a compact, dense medium for conveying the current to the electrode. The stuffing box is made of copper and water-cooled; it is enlarged toward its outer end so that the withdrawal of the electrode tends to loosen the packing. (908,407, Dec. 29, 1908.)

Carborundum.—For the production of carborundum, such a high temperature is required as is obtainable only in an electric furnace. But this does not mean that all the heat must be produced electrically. As the process is essentially discontinuous and the charge has first to be heated up to the temperature of reaction, Mr. F. J. Tone, superintendent of the Carborundum Company, proposes to use no electric heat for this lower temperature range, but to heat the charge up by means of gaseous products of combustion. These may be carried either around a cylinder containing the charge or through the charge, several constructions being described. When the charge has been preheated in this way the electric current is turned on and the production of carborundum starts. Naturally there is a considerable economy in preheating in this way in comparison with the expensive electric heat. (908,357, Dec. 29, 1908.)

Nickel from Silicious Ores.—Mr. E. F. Price, general manager of the Union Carbide Company, smelts a silicious ore of nickel and iron in an electric are furnace to produce ferronickel. Sufficient carbon is used in the charge, not only to reduce the nickel and iron, but to protect the carbon electrodes from oxidation. Instead of the arc furnace, a resistance furnace may be employed for reduction. The resulting ferronickel is then treated to remove the iron by oxidation, by blowing air into the alloy. This may be done in the reduction furnace, which for this purpose is provided with tuyères at its lower end for the introduction of the air blast. The alloy is thus electrically heated and maintained in a molten condition by electric heat in addition to that supplied during reduction. Silica for slagging the oxidized iron may be derived from the charge or may be independently added. If the product of reduction contains silicon, the oxidation of this silicon supplies heat to maintain the metal in a molten condition, and the resulting silica combines with the iron oxide. A deoxidizer, such as silicon, ferrosilicon or aluminum, may be added to the high-nickel product before casting it into ingots. (909,666 and 909,667, Jan. 12, 1909.)

Silicon.—Dr. Henry Noel Potter, whose extended researches on silicon and silicon monoxide are well known, has recently been granted another patent in this line. It relates to the production of silicon free from silicon carbide. This patent contains many interesting points. If silica is reduced by carbon, the following three reactions take place simultaneously:

$$Si\,O_2 + 3\,C = Si\,C + 2\,CO.$$
$$Si\,O_2 + 2\,C = Si + 2\,CO.$$
$$Si\,O_2 + C = Si\,O + CO.$$

There are four principal reaction products, Si C, Si, Si O and CO, which separate according to their properties. Si dissolves some or all the Si C and the two flow down till they either freeze or find lodgment before solidifying. The Si O and CO pass off together, the Si O depositing in the gas vents through which C O escapes. The first of the above three reactions cannot be suppressed in any mixture yielding a sufficient quantity of silicon per kw-hour to be commercially efficient. The reason appears to be that fluid Si adheres firmly to Si C and dissolves at least a portion of it and then shields it from reaction with $Si\,O_2$. Increasing the silica in the mixture only facilitates the third of the above reactions. However, there is another reaction for the production of silicon, namely:

$$Si\,O_2 + 2\,Si\,C = 3\,Si + 2\,C\,O.$$

There is no carbon in the mixture and the starting material would be expensive, if crystalline carborundum, Si C, were used. But it is possible to employ "carborundum fire sand," a cheap crude by-product of the manufacture of carborundum. It contains a large amount of Si C, mostly in the amorphous state, also some free carbon and $Si\,O_2$, but varies in composition. It may also contain "siloxicon" (indefinite compounds of the formula $Si_x\,C_x\,O_y$). A sample analysis of carborundum fire sand is 70 per cent Si C, 17 Si O, 7 C and 6 slag. With this fire sand, together with silica and extra coke, a mixture can be made, $8\,Si\,O_2 + 6\,Si\,C + 4\,C$, or by weight 62.4 per cent $Si\,O_2$, 31.4 Si C, 6.2 C. This mixture treated in the electric furnace yields a large amount of Si per kw-hour (in an actual case over 50 grams of silicon per kw-hour), but this silicon must be purified and freed from any contained Si C in a second step.

The principle of the purification process is as follows: Fluid silicon does not dissolve carbon, but dissolves silicon carbide. Further, Si C and $Si\,O_2$ react readily beneath a bath of fluid silicon, the products being either Si or Si O, or both and C O; also Si C can react with Si O, the products being Si and C O. Hence if $Si\,O_2$ be present beneath a bath of fluid Si, then the $Si\,O_2$ and contained Si C can react, while any Si O liberated may react with Si C, so that the final products are Si, which adds itself to the silicon already present, and C O, which escapes. The temperature is sufficient to cause a bed of granular quartz sand to fuse into a vitreous mass of sufficient sustaining power to support the fused silicon in a hollow formed in the silicon

bed. A very satisfactory arrangement is to use an electric arc furnace with vertical co-axial electrodes, the lower surrounded near the arc by a bed of silica upon which, surrounding the arc and upper electrode, is a mixture of the composition $8\,Si\,O_2 + 6\,Si\,C + 4\,C$. The mixture upon the bed must be deep enough to prevent the furnace blowing, which occurs when the escaping C O gas opens a large vent through which it escapes, carrying Si O, $Si\,O_2$ and Si as dust or vapors with it. If the C O escapes through a porous mass of crushed carbon, for example, it is cooled enough to issue alone. It is an advantage to have both electrodes movable, and it is also an advantage to operate a long arc at about 150 volts or more, rather than at 100 volts. The specification contains some further details of operation. (908,130, Dec. 29, 1908.)

Sodium Peroxide.—"Oxone" or fused sodium peroxide is made, according to Mr. D. E. Parker, as follows from powdered peroxide: The powdered peroxide is heated electrically in a ladle with the aid of two electrodes dipping into it. The action is started by means of a temporary removable electric resistance; when the peroxide is molten, it is a conductor and then forms itself the resistor. The temperature is kept between 710° and 718°. The melting pot is then tipped and the fused peroxide is run into water-cooled molds. (909,017, Jan. 5, 1909.)

Electrolytic Processes.

Chlorine and Caustic by Mercury-Cathode Process.—Two patents of Mr. C. F. Carrier, Jr., refer to details of the mercury-cathode cell. One has to do with the method of circulating the mercury continuously between the electrolyzing and oxidizing compartments. The electrolyzing compartment is in the center, the oxidizing compartment is arranged in circular ring form around the former and separated from it by a circular wall. The bottom of the electrolyzing compartment has an opening in the bottom from which conduits lead to the outer oxidizing compartment. These conduits are filled with mercury and the opening in the bottom of the electrolyzing cell contains a centrifugal pump which provides the circulation of the mercury. This pump is made of earthenware and its rotor has a relatively slow movement, while the mercury conduits have a relatively large cross section, in order to procure a quiet and uniform flow of the mercury. Like the casing and rotor of the pump, the mercury conduits are made of earthenware. This is important in order not to contaminate the mercury. (908,546, Jan. 5, 1909.)

A second patent of Mr. Carrier refers to the decomposing cell in which the sodium amalgam gives off its sodium, to form caustic soda. It is known that this reaction is accelerated by local action. Mr. Carrier uses for this purpose graphite bars extending above the surface of the amalgam to a sufficient height to permit a substantial difference in the density of the caustic soda solution in contact with the bars. This height is preferably not less than 2 inches. (908,545, Jan. 5, 1909.)

Chlorine and Caustic by Diaphragm Process.—Mr. Marcus Ruthenburg uses a diaphragm cell of circular form containing a porous cup. The anode compartment is inside and closed, the chlorine gas being drawn off through a tube in the top. The cathode compartment is outside of the porous cup and open to the atmosphere. The cathode is a cylinder of wire cloth, formed of volute layers encircling the local porous cup. A number of such cells are connected in a series and the cathode compartment of each cell is connected with the cathode compartment of the next cell by means of a pipe leading from the bottom of the former to the top of the next cell. The scheme is to deliver the lower concentrated portion of the sodium hydrate solution in the cathode chamber of each cell to the cathode chamber of the next, and so on through the series, in order to get a gradually increasing concentration along the series. (898,785, Sept. 15, 1908.)

Plating Chains and Rolls.—Two patents were recently granted jointly to Mr. Abraham Van Winkle, the distinguished pioneer of the electroplating industry in this country, and Mr. John T. Daniels. Both patents refer chiefly to the mechanical arrangement and are distinguished by effective simplicity of design. The first patent refers to the plating of heavy chains, arranged in the form of continuous loops moving upon and about conveying rolls or drums. The chain is suspended from a revoluble roll above the plating tank and is in rolling engagement with it so as to be moved continually through the plating solution. At the same time the chain moves along a revolving brush so as to produce a bright or burnished electrodeposited surface. (907,425, Dec. 22, 1908.)

The other patent refers to the plating of tubes, pipes, etc. The apparatus comprises one or more contact-producing and supporting rolls, upon which are arranged metallic chains, forming good electric conductors. In the loops are deposited, in rolling relation with each other, piles of tubes, pipes, rods, etc., to be plated. (907,426, Dec. 22, 1908.)

Removal of Metallic Plating.—A process for removing copper, nickel and zinc coatings from metallic surfaces is patented by Messrs. T. R. Bayliss, W. R. Hodgkinson, J. H. Hardcastle, A. H. Coote and R. A. E. Payne. The process is especially useful for the removal of the metallic fouling from the "lands" or "grooves" of the bore of a breech-loading gun. The process consists simply in using the surface to be stripped as anode in an electrolyte containing 2 per cent by volume of glacial acetic acid, 15 ammonia (0.88 specific gravity), and 83 water. (908,937, Jan. 5, 1909.)

Discharges Through Gases

Ozone.—Mr. W. Koelle has modified the Elworthy ozonizer, which consists of dielectric tubes with inner and outer conductors out of contact with the dielectric tubes. Electric discharges take place between the conductors and the adjacent walls of the dielectric and the air is ozonized by passing first through the interior of the tube and then over the outside. In Koelle's modification a number of tubes are arranged concentrically with coils supported at a short distance from the walls, so that the outer coil on one tube forms the inner conductor for the dielectric tube of the next larger diameter surrounding the first tube.

RECENT METALLURGICAL PATENTS.

Iron and Steel.

Removal of Sulphur from Steel in the Electric Furnace.—The reactions and processes by which sulphur is removed from steel in the electric furnace were discussed at length in three papers by Geilenkirchen, Osann, and Harden in our October issue, 1908 (Vol. VI, p. 405). With reference to these papers, the following note from London *Electrical Engineering*, Dec. 17, is of interest. The reduction of sulphur in the electric furnace depends on its combination with calcium, and not, as in the case in other metallurgical processes, with manganese. The desired conversion of iron sulphide and of manganese sulphide (in the steel bath) into calcium sulphide (in the slag) can only take place in presence of a powerful reducing agent. In the Héroult electric furnace calcium carbide is employed to remove the sulphur, while in the induction furnaces ferrosilicon is used. The desulphurizing power is practically the same in both cases, but the use of ferrosilicon is more expensive. In the Héroult process the calcium carbide is made in situ by the action of the carbon electrodes on the lime slag. It does not, therefore, require to be first made and then added to the furnace charge, consequently it is found to be about $1.25 cheaper per ton of iron smelted than if ferrosilicon were employed. There is also a danger in the use of ferrosilicon that the finished steel may contain too large a quantity of silicon. The employment of calcium carbide to produce a slag poor in metal has been patented by the Elektrostahl-Gesellschaft, German patent 163,519.

Alloy.—J. F. Clapp patents an iron alloy or steel, "characterized by great hardness, toughness, tensile strength and resistance to corrosion." It comprises from 40 to 90 per cent

... 1 to 30 iridium and 0.2 to 10 platinum. To facilitate the uniform solution of the iridium and platinum in the iron, prevent segregation upon cooling, and produce a homogeneous, unsegregated product it is "desirable" to add to the alloy molybdenum 1 to 15 per cent and "preferably" copper (0.5 to 15) ... nickel (0.5 to 15). (909,283, Jan. 12, 1909.)

Lead.

Treatment of Slimes of Refineries.—It is well known that in the development of the Betts process for the electrolytic refining of lead—which is now used successfully at several places—nothing has offered greater difficulties than the treatment of the slimes. At the pioneer Betts refinery in Trail, British Columbia, Mr. Alexander J. McNab has worked out the following process: The slime is first treated with sodium polysulphide, which dissolves antimony, arsenic, tellurium, and selenium. The solution is filtered off and the antimony recovered by electrolysis, the sodium sulphide solution being regenerated. When too much arsenic accumulates in the bath it is removed by evaporation to 35° B. and subsequent cooling. The residue resulting from the treatment of the slime with the sodium polysulphide contains silver (both metallic and as sulphide), lead, bismuth, copper and gold. This is roasted to convert the sulphides into sulphates. By treatment with water or dilute sulphuric acid, the copper sulphate, most of the silver sulphate, and some of the bismuth sulphate is dissolved. This solution is separated from the residue, which consists mostly of metallic gold and silver, lead sulphate, and basic bismuth sulphate. The silver and bismuth is precipitated by copper, and the precipitated metals are melted down in a reverberatory furnace, the bismuth being oxidized off and recovered as oxide, which can be further treated by known methods to convert it into metallic bismuth, bismuth oxychloride, etc. The filtrate resulting from the precipitation of silver and bismuth is concentrated and allowed to stand to crystallize the copper sulphate resulting from the treatment of the original solution with copper, and to recover the free sulphuric acid, which is to be used over again. The residue of metallic gold and silver, lead sulphate and basic bismuth sulphate is charged into a reverberatory furnace, the lead and bismuth oxidized off, and the bismuth recovered. The gold-silver alloy is then parted by well-known methods. (908,603, Jan. 5, 1909.)

Separation of Lead from Zinc.—To separate lead from zinc vapor, E. H. Shortman uses an intercepting medium, consisting of small pieces of coal or coke, preferably anthracite. The anthracite is placed in the end sleeve of the receiver for the purified zinc. This end sleeve of the receiver extends into the interior of the retort, so that the whole vapor must pass through the anthracite. (905,753, Dec. 1, 1908.)

Copper.

Copper-Titanium for Copper Castings.—It is well known that copper, when melting, absorbs gases and is oxidized, to an extent, during fusion, the resulting oxides dissolving in the metal with the result that copper cannot be cast in sand directly from crucibles, or in sand molds made in flasks, or such molds as are used for casting pig iron. Copper cast in this way contains blow holes and cavities to a prohibitive extent. Mr. Auguste J. Rossi, the indefatigable pioneer of titanium (who is now about to see the fulfillment of his life's work, the permanent establishment of a titanium industry), recommends the addition to the copper of from 1 to 2 per cent in weight of combined cupric and titanic materials; for example, an alloy of copper and titanium containing from 5 to 12 per cent of titanium. This alloy is used to the extent of 1 to 2 per cent of the entire weight of copper. The titanium binds the gases, etc. Copper treated in this way can be cast in sand in flasks such as mentioned above, the pouring being quiet, without overflow through the gates, and without piping, and the resulting bars, solid, presenting in practice a close grained, dense structure, free from blow holes.

Aluminothermics.

Substitutes for Aluminium.—In our Vol. VI, p. 360, we printed a paper by Dr. Hans Goldschmidt, describing in detail his experiments on substituting a calcium-silicon alloy or a magnesium-silicon alloy or an aluminium-calcium alloy for aluminium in the aluminothermic reaction. The use of calcium-silicon is now covered by Dr. Goldschmidt's patent, 906,009, Dec. 8, 1908. While the applicability of these alloys is certainly very interesting from a scientific standpoint, the recent drop in the market price of aluminium renders it highly improbable that the alloys will soon supplant aluminium in the industrial applications of the thermit reaction.

Reduction of Pure Metals.—Mr. George O. Seward and Mr. F. von Kuegelgen have also endeavored to find a substitute for aluminium as reducing agent for the production of pure metals. They have found that alloys of the alkali-earth metals (barium, strontium or calcium, either single or combined), with suitable proportions of either aluminium, magnesium, zinc, etc., form brittle alloys which are easily crushed and form a very effective reducing agent. For instance, for the production of chromium from chromium oxide they propose to use calcium magnesium as reducing agent, or for the production of German silver from nickel oxide and cupric oxide they use a calcium-zinc alloy. (908,154, Dec. 29.)

Welding.

Autogenous Welding of Cast Iron.—It is unnecessary to emphasize the difficulties experienced in any attempt to weld two pieces of cast iron together. Mr. A. Beltzer and Mr. C. Delcampe claim to have solved the problem by means of a flux, consisting of 65 per cent potassium chloride, 15 per cent lithium chloride and 20 per cent potassium fluoride. One particular advantage of their process is that it is unnecessary to clean the surfaces to be welded. They proceed as follows: They preheat the surfaces to be welded, sprinkle them with the flux powder, and then heat the surfaces to substantially the melting point. "It is preferred during this heating operation to add cast iron to the joint, and for this purpose a rod or pencil of cast iron is dipped in the flux and presented to the heating flame, where it is melted and flowed onto the joint, much in the same manner that solder is applied to a joint in soldering pieces of tin together, except, of course, that being cast iron, the cooling process is so much faster that each portion of the joint must be finished as the heat is advanced along it. The addition of the flux to the cast-iron rod, which is melted on a joint, is for the purpose of refining the cast iron as it is applied to the joint, so that it will form a union with the pieces of cast iron to be welded, and also to bring some flux into the molten metal of the pieces to be welded.

"Blow holes may be filled by the addition of cast iron in the above-described manner, so also errors in workmanship may be cured by adding cast iron to surfaces where too much has been removed, or, again, a protuberance may be formed by adding cast iron at any particular place where it is desired. A valuable feature of the invention consists in this, that when such cast iron is added to an original casting or piece the added portion and its joint with the original iron are stronger than the original casting." The inventors state themselves that "the invention is based upon principles which are not fully understood," but they believe in a general way that "the operation is based upon the affinity of the halogenides and the halogenide acids for the impurities of the cast iron."

Welding Copper.—For welding copper Mr. James Crew patents a composition consisting of the following ingredients, viz.: 10 parts borax, 8 parts carbonate of iron, 3 parts alum. These ingredients are thoroughly mixed together and a suitable amount of the mixture is placed on the joints or ends of the copper intended to be welded; after first heating the copper to a sufficient heat, the joint is hammered together as in welding iron. (906,202, Dec. 8, 1908.)

Exhibition of Chemical Engineering Apparatus and Machinery.

A special feature of the Pittsburgh meeting of the American Institute of Chemical Engineers, on Dec. 28 and 29, was an exhibition of various apparatus, machinery and appliances of interest to chemical engineers. This exhibition had been arranged in the basement of the Carnegie Technical Schools and attracted a great deal of attention.

Pyrometers.

The **Leeds & Northrup Company** of Philadelphia had an exhibit of two of their latest designs of pyrometers, in charge of Mr. C. R. Cary. Dr. E. F. Northrup, who himself attended the meeting, read a paper on modern resistance pyrometry, which is given in abstract on page 62 of this issue.

One of the pyrometers exhibited was the indicating self-checking instrument which was described and illustrated in our January issue, page 44.

The second pyrometer exhibited was an entirely novel type of recording instrument. The recorder is primarily designed to give a continuous record of temperature changes, but as the movements of the recording pen can be made to respond to changes in electromotive force or changes in electrical resistance, it is obvious that the instrument may be made to record many other quantities than temperature. The instrument

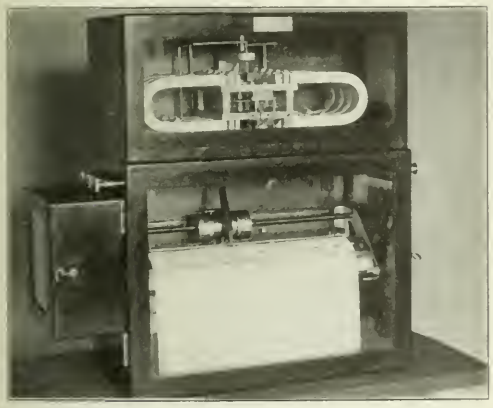


Fig. 1. RECORDING PYROMETER.

consists essentially of three parts: (1) A large and robust differential galvanometer which carries on its moving part a small piece of platinum rod. Attached to the galvanometer frame is a small plunger magnet which at two second intervals causes the above piece of platinum to make contact if the galvanometer is off balance with a piece of silver on the right-hand side of the small ivory strip or with a piece of silver on the left hand side of this ivory strip. If the galvanometer is balanced, the piece of platinum is brought into contact with the ivory strip and no electrical contact is made. (2) A Seth Thomas clock, which performs the double function of advancing the paper at any desired speed within wide limits, the standard speed adopted being three inches an hour, and to make at two second intervals a contact which operates the small plunger magnet which causes the above piece of platinum to make contact. (3) The record portion, which consists of a paper drive and apron over which the paper travels and a stylographic pen used to trace a line upon this paper. The same mechanism that advances the pen also moves a sliding contact over a spiral of resistance wire.

The recorder has been designed to give the record on a continuous strip or sheet of cross-section paper, ruled in rectilinear coordinates. The movements of the recording pen are strictly proportional to the temperature changes being measured. This recorder would be most commonly used in the measurement of temperature with a resistance type of thermometer or pyrometer. While it is well known that the temperature coefficient of platinum or other wire used for pyrometers is not a linear function of the temperature, the recorder nevertheless gives a record which is proportional to temperature changes, even though the resistance changes in the pyrometer are not proportional to the temperature.

This instrument is susceptible of great sensibility. The portion of the record shown on which the record is traced is 10 in. wide and this 10-in. interval may correspond to as little as 4 deg. C., while the movements of the pen will respond in this case to temperature variations of 0.02 of a degree Centigrade, thus giving a record of temperature to an accuracy of $\frac{1}{2}$ per cent when the temperature interval being measured is only 4 deg.

When the temperature interval being measured is 100 deg. or more, the instrument can be made to record to an accuracy of $\frac{1}{4}$ per cent of the temperature interval being measured, without alteration in any of the mechanical features of the instrument.

The temperature range can be varied through very wide limits by simply changing a shunt resistance and the same instrument may be made to give a temperature record from 800 deg. to 1000 deg. or 600 deg. to 800 deg. by simply changing the fixed resistance. All parts of the apparatus are easily removable as separate units, and all the separate units into which the apparatus may be separated are entirely interchangeable so that if any part should fail to operate this part may be quickly replaced by a new part.

The apparatus being exhibited at Pittsburgh was recording the variations in the temperature of an electric oven produced by varying the current through this oven in a range of 500 deg. C. to 1000 deg. C. The features of the apparatus are on principles not heretofore used in either the measurement or the recording of temperatures.

* * *

Chemical Stoneware.

The **Didier-March Company** of New York had quite a large and interesting exhibit, which was in charge of Mr. G. S. Hessenbruck, contracting engineer of the company. This firm devotes one entire plant to the manufacture of acid-proof chemical ware. This chemical ware is identically the same grade and class of material as is imported from Germany. They manufacture all of their various products at their works at Keasbey, N. J., using, however, imported raw material. It is a great advantage that this class of material is now being made in this country.

Their exhibit, though not showing their whole line of manufacture, comprised the following articles: Tourills, system cellarius, suction filters, injectors, acid-proof centrifugal pump, and various kinds of bib and flanged cocks of various diameters.

The article which attracted particular attention was the so-called cellarius cell shown in Fig. 2 on page 90. This cell is a vessel resembling in cross-section a semi-circular arch, with a very large surface in proportion to the quantity of liquid it contains, the arrangement being such that the entire surface can be cooled. The cell is mostly used in modern hydrochloric acid plants, and is so efficient that by good cooling an acid can be directly obtained of a strength of 24 deg. Bé. The absorbing liquid enters through an inlet on the front side of the tourill, travels to the end and crosses the saddle in a broad stream, and then flows along the other side before it escapes through the outlet on the front side. It, therefore, travels twice the whole length of the vessel, always being cooled by contact with the bottom of the cell, which is immersed in water.

An acid pump exhibited was an ordinary centrifugal pump, having, however, a stoneware lining and stoneware impeller, so that it is suitable for the handling of any kind of acid without

...y d... ...acid affecting or destroying any of its parts. The various kinds of cracks that were shown were admired for their smoothness and evenness of grinding, and the sizes of these cracks varied all the way from $\frac{5}{8}$-in. to $2\frac{1}{2}$-in. inside diameter.

The Drory-Marchi Company also exhibited a number of plans of various processes for which the company has the sole right of manufacture in this country. Among them were plans

FIG. 2.—CELLARIUS CELL.

and elevations for bromine refining apparatus, nitric acid condensing plant, denitrating plant for spent acid, regenerating plant, storage plant for storing 33 tons of acid, continuous bromine refining plant, nitric acid plant system Valentiner, hydrochloric acid condensing plant.

* * *

Pulverizing Mill.

The **Fuller Engineering Company** of Allentown, Pa., had an interesting exhibit, which centered on the Fuller-Lehigh pulverizing mill. The Fuller mill is extensively used by cement manufacturers, and in order to show the simplicity of arrangement of a Portland cement plant equipped with Fuller mills complete plans of the Seaboard Portland Cement Company and the Allentown Portland Cement Company were shown. Supplementing this was a complete model of the Fuller mill, which showed in detail the construction and operation of the machine.

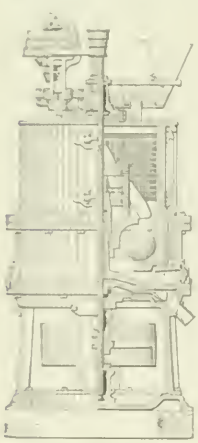


FIG. 3.—FULLER MILL.

That the machine is not confined to the cement industry alone was evidenced by a variety of materials shown in sample jars; all these materials were pulverized by Fuller mills, and among them may be mentioned talc, coal, coke, charcoal, chrome ore, iron ore, blast furnace slag, puddlers' slag, quartz, barytes, fluorspar, silica, caustic lime and phosphate rock, and even such exceedingly hard material as titanium carbide.

The Fuller mill is made in two sizes, 33 in. and 42 in., these being the diameters of the dies used in the respective machines. The material to be reduced is fed to the mill from an overhead bin by means of a feeder mounted on top of the mill. This feeder is driven direct from the mill shaft by means of a belt running on a pair of three-step cones, which permits the operator to accommodate the amount of material entering the mill to the nature of the material being pulverized.

The grinding is done by means of four unattached steel balls, which are propelled by four equidistant horizontal arms or pushers radiating from a vertical central shaft. The material discharged by the feeder falls between the balls and the die and is reduced to a finished product in one operation.

Above the die and the balls is a fan which is attached to the yoke propelling the balls. This fan has two rows of fan blades, one above the other. The lower set of fan blades lifts the finished product from the pulverizing zone into the chamber above the die, where it is held in suspension until it is floated out through a screen by means of the fanning action of the upper row of fan blades. The finished product is then discharged through a spout, which may be placed at any one of four quarters of the mill.

The balls of the 33-in. mill are $9\frac{1}{4}$ in. in diameter, weigh about 118 lb. each and are propelled at a speed of from 200 to 210 revolutions per minute. The balls of the 42-in. mill are 12 in. in diameter, weigh about 260 lb. each and are propelled at a speed of from 150 to 160 revolutions per minute. The mill is driven by belt, as shown in the adjoining figure, or may be driven by a motor coupled direct to the shaft.

The only parts subject to wear are those parts which come in direct contact with the material being pulverized, and, as the entire pulverizing action takes place in a limited zone, the wear and tear is reduced to a minimum.

The Fuller mill is self-contained and requires no accessory equipment. It is shipped assembled complete and is ready for operation as soon as placed on the foundation. Inasmuch as neither the 33-in. or 42-in. mill requires a greater floor space than 7 ft. square, the cost of installation is reduced to a minimum. The material delivered by the mill is a finished product and requires no subsequent screening. Power cost and maintenance cost are low. The exhibit of the Fuller Engineering Co. was in charge of Mr. Hachtman.

* * *

Welding and Cutting by the Oxy-Acetylene Flame.

The exhibit of the **Davis-Bournonville Co.**, of New York City, was in charge of Mr. Henry Cave, president of the Autogenous Welding Equipment Co., of Springfield, Mass., representing the former company in the New England States. The exhibit comprised oxy-acetylene cutting and welding torches and various samples of welds and cuttings made in this way.

As we have explained in numerous former articles on this subject, the burner for welding has simply two supply pipes, one for acetylene, the other for oxygen gas, and a temperature is thereby produced considerably higher than that of the oxy-hydrogen flame. The burner for cutting is like the burner for welding, but has an additional supply pipe for oxygen gas: its action is in two steps—first, the parts to be cut are highly preheated by the ordinary oxy-acetylene flame; then the current

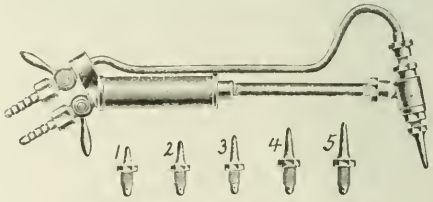


FIG. 4.—OXY-ACETYLENE TORCH.

of oxygen gas from the additional supply pipe produces spontaneous combustion of the metal. (See, for further details, M. U. Schoop, this journal, 1907, Vol. V, page 308.)

The equipment, therefore, comprises an acetylene pressure generator, an oxygen generator, oxygen cylinders, an acetylene regulating valve, an oxygen reducing valve, gauges, etc., and high-pressure torches (Fig. 4). The torches were exhibited in two sizes, each having five interchangeable tips and the necessary high-pressure hose for supplying them with gas.

The gases pass from the hose into the torch and thence into the tip, the oxygen passing in through a small hole in the center of the inner end of the tip, while the acetylene enters at the side, striking the oxygen current at a right angle. This provides a very intimate mixture, which only requires a volume

of oxygen 1.28 times that of acetylene to give complete combustion, resulting in a neutral flame having a temperature of from 6000 to 7000° Fahr.

The holes in the inner end of the tip regulate the flow of the gases so that the proportions of the mixture are constant under all conditions. No outside influence, such as a particle of metal adhering to the tip, can make the flame either oxidizing or carbonizing, as would be the case if the torch worked on the injector principle.

For convenience acetylene dissolved in acetone was used in the demonstration instead of the pressure generator. The oxygen was used in compressed form in a cylinder. Mr. Cave welded numerous samples of cast iron, steel and aluminium and also welded cast iron and copper to steel, one of the interesting features being the softness of cast iron after being treated in this manner.

A steel plate was also cut very readily with a jet of oxygen, applied from a cutting jet (additional oxygen jet) attached to the large welding torch. A corner of the metal was first brought to red heat by the oxy-acetylene flame, and then the metal was cut by oxidizing it away with the additional oxygen jet. After the cutting of a portion of the metal has been started the heat of combustion brings the portion to be cut afterward to a sufficiently high temperature to make the application of the cutting oxygen jet directly effective.

The intense heat of the oxy-hydrogen flame was very impressively demonstrated by applying it to the corner of a fire brick which melted and began to flow in two or three seconds. An interesting sample of cast iron welding, which was exhibited, is illustrated in Fig. 5. It shows a motor-cycle combustion head, having had part of the flange welded in and metal added to strengthen the exhaust part, thus saving the necessity of a new pattern and casting.

A pressed steel globe valve was also shown, the parts having been welded up by this process. In this way a perfectly reliable valve was obtained, the thickness and strength of the parts being known, which is not the case with the common cast valve, this making it very suitable for high-pressure work.

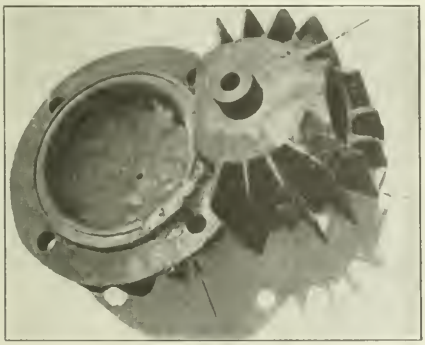


FIG. 5.—OXY-ACETYLENE WELD.

A sample was shown of sheet steel, nickel plated and welded up along the seams; this weld clearly showed the non-oxidizing nature of the flame by the fact that the nickel flowed over the weld, replating it automatically. This method of welding is now used for welding the seams of the containers of the Edison nickel-iron battery.

Another interesting specimen which demonstrated the localization of the heat consisted of a number of catalogues with holes punched in them, through which steel rings were inserted, the joints of the rings being welded without even scorching the paper.

Valve for Corrosion Liquids.

The **Cleveland Bronze and Brass Works** of Cleveland, Ohio, had an interesting exhibit of their acimet valves for corrosive liquids, in charge of Mr. Wm. H. Bloom.

Fig. 6 gives an external view of the globe pattern of the acimet valve, while Fig. 7 is a sectional view, showing the interior construction with the reinforced disc and seat.

The chief features are the use of "acimet" metal, a special lead alloy which eliminates any chance of corrosion, and the reinforcement of the acimet metal by means of a bronze structure which gives the required mechanical strength to withstand heavy pressure. These two features make the acimet valve of greatest usefulness in many industries where acids are either made or used in large quantities, as the employment of this valve does away with the familiar troublesome necessity of reseating and repairing at frequent intervals.

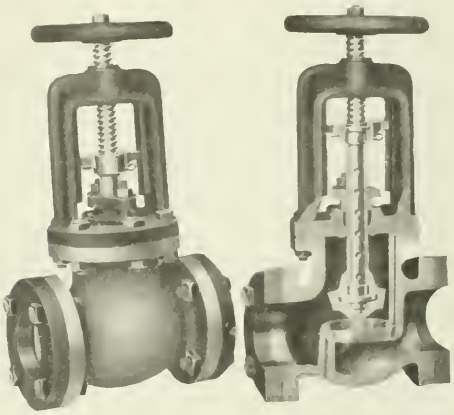


FIG. 6.—OUTSIDE VIEW.

FIG. 7.—SECTION ACIMET VALVE.

The body of the acimet valve is made of the special acimet metal reinforced, as shown in Fig. 7. A bronze ring is cast in the center and supported as shown, entirely surrounded with acimet metal, making a strong, rigid support. The yoke is made of cast iron, the stuffing box and the flange of the same being lined with acimet metal in the same way as the body. The screw is made of bronze with a four-pitch thread, making it quick opening. The valve stem is so constructed that it will not turn, similar to the loose disc valves, so as to do away with constant friction and to give a much longer life. Seating in the same place, entirely eliminating friction, there is very little wear; this, of course, also prolongs the life of the valve

The connecting flanges are made of cast iron. Bolts are furnished with all flanges. Threaded flanges can be furnished also for iron pipe lines.

* * *

Evaporators.

The **George M. Newhall Engineering Company, Ltd.**, of Philadelphia, exhibited drawings of three principal types of exaporators built by them. They are shown in Figs. 8, 9 and 10.

Fig. 8 shows the salt evaporator used for all precipitation work, including that of salt brine, caustic brine, sodium carbonate and bichromate. It is built of flange boiler steel with cast-iron steam boxes and wrought iron vapor pipes. This is the most economical construction in the precipitating evaporator, containing the least amount of metal per square foot of heating surface.

Fig. 9 shows the concentrating evaporator, used for all classes of foamy liquors, including sodium carbonate, caustic soda,

sodium phosphate, and certain

iron or cast steel, the vapor pipes are of wrought iron or boiler steel.

In all three diagrams *A* represents the steam inlet and *C* are the heating tubes.

Referring to Fig. 8, showing the salt evaporator, *F* is the vapor space over the boiling solution, *G* a baffle plate, and *H* the vapor nozzle. *C* are channels bracing the side walls.

In Fig. 10, *A* is again the steam nozzle, *B* and *D* the front and rear steam boxes, *a* and *b* are channels bracing the steam box covers.

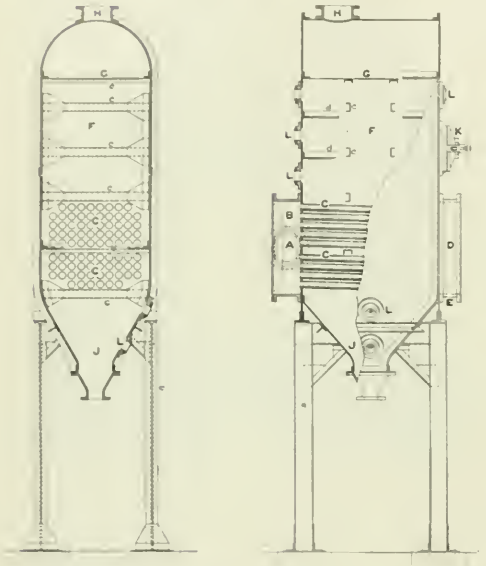


FIG. 8.—SALT EVAPORATOR.

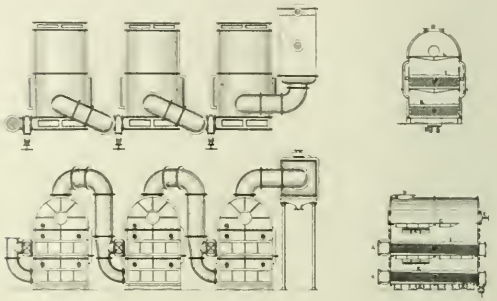


FIG. 10.—SUGAR EVAPORATOR.

Otherwise the three diagrams are self-explanatory. These three types of evaporators are believed to be adaptable to almost any evaporator problem that may arise.

The **Zaremba Company** of Chicago also had a fine and very instructive exhibit, in charge of their chief engineer, Mr. Otto Mantius. It comprised a model of Mr. Edw. Zaremba's patent evaporator and also a set of drawings showing types of some of their various evaporating systems. An illustrated description of the same must be reserved for a later issue.

Shaking Device for Laboratory.

The **Scientific Materials Company** of Pittsburg exhibited in operation the motor-driven shaking device for the chemical laboratory, which is an invention of Mr. J. M. Camp, chief chemist of the Carnegie Steel Company at Duquesne, Pa. This shaking device was fully described and illustrated in our Vol. V, p. 270.

Enameled Pipe.

The enameled pipe now being placed upon the market by the Enameled Pipe & Engineering Company, of Cleveland, Ohio, has proven to be absolutely rustproof, acidproof and alkaliproof and is being used successfully in mines, paper mills, chemical works, pulp mills, reduction works, chemical laboratories, oil wells, oil pipe lines and similar places, where the acid or alkaline conditions of liquids or gases would cause the rapid deterioration of any metallic pipe.

Another valuable feature of this enameled pipe is that it is not subject to electrolysis, so that electric currents do not affect it in the slightest degree. The Enameled Pipe & Engineering Company also guarantees their pipe to stand any pressure that standard steel pipe will stand.

In the process of manufacture the steel pipe is provided both inside and outside with a coating of hard vitreous enamel, which in some ways has the consistency of glass, but it is much harder, more flexible and tougher and is absolutely proof against the action of acids or alkalies. This enamel is not a paint and does not have in its makeup any japan, resin or coal tar products. The enamel will not come off, craze or scale from any cause unless it is hit with a sledge, and the pipe need not be handled any more carefully than sewer pipe.

The fittings for the enameled pipe are made heavy to with-

stand high heads, are coated with the same enamel as the pipe and are manufactured so as to produce all the results that common pipe fittings will produce. The company manufactures a full line of couplings, reducing couplings, elbows, forty-fives, crosses, tees, etc. These fittings have been tested to stand a pressure of 500 lb., and where the conditions demand it they can be furnished to stand higher pressures.

There are no threads in the fittings or pipe, and if properly installed there will be no break in the enamel in any way, thus producing a system of piping in which the liquid or gas cannot come in contact with any metal whatever.

The fittings used are very simple and are more easily attached, requiring less skill to install than common pipe fittings.

Enameled pipe is furnished in one-half the random mill lengths of common steel pipe. On special order extra strong and double extra strong pipe for high pressures can be furnished.

The packing furnished with the fittings is molded expressly for this pipe, and no cutting or trimming is required. Unless otherwise ordered, the packing is made of a specially prepared and compounded rubber, which has been found to resist the action of acids and chemicals better than any other compound experimented with.

The entire system of piping when installed is absolutely indestructible from the action of any chemicals attacking the pipe from either side, as both sides of the pipe and both sides of the fittings are thoroughly coated with the enamel, which prevents any chemicals from attacking or decomposing any metal contained in the piping system. The only exception are the bolts with which the couplings are put together, and these bolts are furnished, made of any metal that the purchaser desires.

Enameled pipe is furnished in all sizes from 2 in. and up in the standard sizes of pipe. The Enamel Pipe & Engineering Company maintains a corps of experts and engineers to assist its customers on any of the engineering problems which may confront them in connection with piping work.

Samples of this pipe have been tested in some of the largest copper mines of the West and coal mines of the East in the following way: Part of the piping system was made of this enameled pipe, while the rest of the pipe was left bare. The result was that in some cases within 33 days the entire unprotected portion was eaten up by the action of the mine water, due to the acid contained in it, while the enameled portion of the pipe remained absolutely perfect.

Dry Blast.

In our December issue (Vol. VI. p. 509) we noticed a recent patent of Mr. Louis Block, consulting engineer of New York City, for a method of drying the air for blast furnaces and converters. It will be interesting to describe here the manner in which Mr. Block proposes to carry out his method in practice.

In the adjoining diagram, which shows the arrangement, *A* is the blowing cylinder; *B* is the condenser and heat exchanger combined; *C* is the expansion cylinder, driving air compressors, pumps or other machinery. The trap to take away the water precipitated on the tube surfaces in *B* is also shown.

The pressure of air delivered to the furnace is assumed to be 17 pounds per square inch.

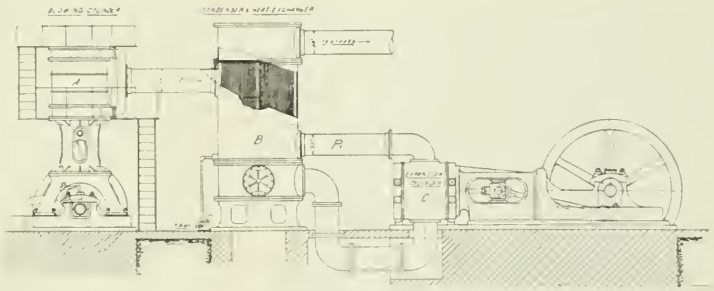
The beginning of operation will then be as follows:

The air is compressed in *A* to 25 pounds, it flows through pipe *P'* into condenser *B*; leaves then *B* through *P''* and is admitted to the expansion cylinder still under 25 pounds pressure. The air is cut off by hand adjustable Corliss valves exactly in the same way as in a steam cylinder and the air expands down to furnace tension, 17 pounds per square inch, and exhausts at this pressure, and at a temperature 45 deg. lower than it entered into the tubes of heat exchanger *B*, cooling the hot air delivered by the blowing engine into the space surrounding the tubes, while it warms itself and passes on to the stoves.

The cumulative effect of the cooling action is as follows:

The air leaving the blowing engine has a temperature of 235 deg. Fahr. It travels through *B* into *C*, is expanded down to 17 lb. while doing work, and is reduced to 190 deg., at which temperature it enters the tubes of *B*, cooling the air surrounding the tubes to 205 deg. The air now expands in *C* and is reduced to 160 deg., it again enters the tubes of *B* and cools the air coming from the blowing engine to 175 deg., the so-called air expands in *C* and its temperature is thereby reduced to 130 deg. and at this temperature it enters the tubes of *B*, cooling the incoming air to 145 deg. This expands and is reduced to 100 deg., and in turn cools the air in *B* to 115 deg., then to 80, to 50, to 20 deg., etc.

If the operation were continued without change, unnecessarily low temperatures would be produced. The cut-off in *C* is now



DRY BLAST.

set so as to cut off later; this reduces automatically the pressure of the air delivered by the blowing engine, to, say, 22 pounds or less, until a point is reached at which the process is so balanced that the air will leave the expansion cylinder *C* constantly at near 30 deg. The air, at a pressure of 22 pounds, is now with the same constancy cooled to 40 deg., at which pressure and temperature its moisture is precipitated. This condition is reached within 30 minutes after the beginning of operation and is maintained without change indefinitely.

At 40 deg. the cubic foot of air contains 2.85 grains of water, and since the air is at a pressure of 2.46 atmospheres absolute it would contain $2.85 : 2.46 = 1.16$ grains per cubic foot at atmospheric pressure.

In order to reach the same result with ammonia refrigerating machines, atmospheric air must be cooled to 17 deg. Fahr. at an expense during the summer months of 2 hp per ton of furnace capacity, or 1000 hp for a plant cooling the air required for a 500-ton furnace.

The horse-power required by the method here described is calculated by Mr. Block as follows:

To compress 50,000 cubic feet of air per minute to 17 lb. gauge pressure, requires 3200 hp, and to compress the same quantity of air to 22 lb. pressure requires 3750 hp, or 550 hp more. Of this 550 hp 30 per cent may be recovered in the expansion cylinder; hence the net horse-power required for drying 50,000 cubic feet of air per minute, of whatever the moisture content of the air may be, is 370 hp, as compared with 1000 hp if ammonia refrigerating machines are used.

Electrolytic Plant for Paper Mill.

An important contract for electrical machinery has just been placed by the Oxford Paper Company, of Rumford Falls, Me., with the Western Electric Company. The machinery purchased includes five motor-generator sets consisting of five 500-hp, 2,200-volt induction motors, each driving a 330-kw, 230-volt, direct-current generator, with motor-driven exciters and a 3-panel switchboard. Power is to be taken from the line of the Rumford Falls Power Company, which is increasing its plant for that purpose. Everything is of the most modern type and designed to include the latest improvements in apparatus of its class.

This electrical machinery is to be used in a large new plant which the Oxford Paper Company is now building at its Rumford Falls mills, to manufacture, for its own use, bleach liquor and caustic soda by a new electrolytic process invented by Jasper Whiting, of Boston, and developed under his direction during the past three years to a point where it is said to have obtained a high degree of efficiency. The Whiting process, which is a mercury-cathode process, was described in its essentials in our Vol. VI, p. 158. It is claimed to be exceptionally economical as regards the use of power and to require only a minimum amount of labor in its operation. The Oxford Paper Company expects a very great saving in the cost of manufacture of pulp and paper from the installation of this plant.

Triplex Buffs for Plating and Polishing Shops.

The cotton buff is one of those small things needed in every plating and polishing shop in such large quantities that it becomes quite a serious item of expense. Just for this reason many platers used to buy the cheapest buff in the market, but long ago this was found to be bad policy, since by using a better quality of buff the number of buffs needed could be greatly cut down, the work done by buff depending directly on the amount of long, hard-twisted fiber in the muslin used.

TRIPLEX BUFF.

The "triplex buff" placed on the market by the Zucker & Levett & Loeb Co., of New York City, is a further step in the right direction. Its special feature is the fold, the prime object being to produce a cross-cutting or diagonal surface on the cutting face of the buff. The buff is made of a succession of folds so formed as to offer a greater surface to the work and at the same time to save composition. The mesh of the fabric, crossing as described, prevents the material pulling out or fraying on the working edge. The triplex buff uses up every strand of thread in the wheel.

On account of this peculiar make-up, the triplex buff is stated to have the following chief practical advantages: It does at least double the work of ordinary buffs; it saves about 20 per cent in composition; it can be used for cutting or coloring up; and finally when the wheel is worn down to, say, 7 inches the stubs may be returned to the manufacturers, and at a nominal cost they are remade into a 12-in. wheel, using two worn-down wheels to make one new wheel of approximately double the diameter.

The Cement Industry in 1908.

From a statement on the American Portland cement industry during 1908, prepared by Mr. Edwin C. Eckel for the United States Geological Survey, we quote the following:

Although detailed figures are not yet obtainable, an estimate based on the information available indicates that the production of Portland cement in the United States was somewhat less than 40,000,000 barrels. This compares as follows with the output of recent years:

1905	35,246,812	barrels.
1906	46,463,424	"
1907	48,785,390	"
1908 (estimated)	40,000,000	"

The falling off from the 1907 output was heavy, and is particularly notable because it is the first decrease shown in any year by the American cement industry since its inception. The decrease was not uniformly distributed throughout the country, for New York, Pennsylvania and New Jersey will probably show the highest percentages of loss, while in some portions of the West and the Middle West the decrease was relatively slight.

The year 1909 opens with heavy stocks of cement on hand at most mills, but with good prospects for a steady, though slow, revival in the cement trade. It is unlikely that this revival will be sufficiently rapid to push mills to their capacity during the year, and it is therefore possible that the high record for output made in 1907 will remain unbroken for another year at least. The total maximum capacity of existing plants is now about 60,000,000 barrels a year.

Draft in Steam Boiler Practice.

A preliminary bulletin on "The Significance of Drafts in Steam-Boiler Practice" is soon to be issued by the Technologic Branch of the United States Geological Survey. The authors, Walter T. Ray and Henry Kreisinger, in carrying out the particular work assigned to them in the general plan for the conservation of the fuel resources of the country, have this to say on their investigation:

The experiments so far made seem to indicate that it is possible to double or treble the capacity of a plant without making any radical changes in the furnaces and boilers. These increases require about double and treble the quantities of air to be put through the fuel beds and boilers. It also seems probable that rebaffling the boilers will often permit the capacity to be doubled or trebled, while still getting more steam than formerly per pound of coal for uses outside the boiler room.

These experiments were undertaken with the object of clarifying ideas concerning the passage of air through fuel beds and boilers. Measured weights of air were passed through two beds of lead shot, in series, one of which remained always the same and represented a boiler; the other being varied as to size of shot and depth of bed, and representing a fuel bed. Careful observations were made of the weight of air passing through the beds per minute. All data were plotted in many charts, so as to permit the study of them from several points of view. A number of laws were deduced bearing on the relative amounts of power required to force air through fuel beds of various thicknesses, composed of various sizes of coal, and through boilers of various lengths and areas of gas passages.

An important part of the discussion relates to an increase in

the capacity of boilers by increasing the amounts of power which must be applied to pressure and exhausting fans in order to force several times as much air through the fuel beds and boilers.

It may be possible, as a result of these investigations, to raise the rate of working the boiler heating surface to three or even four times its present value. Such an increase would undoubtedly mean new designs of grates, stokers, furnaces and boilers, especially fitted for high rates of working. Fan equipments designed to supply three or four times as much air under several times the pressure would be provided with more efficient engines, which is an additional factor favoring high-capacity working.

It must be borne in mind, as stated above, that the results are tentative. It will cost money to force gases at high speeds through fuel beds and boilers, and there will soon be pressing need of such quantitative data as will enable the largest possible part of the energy imparted by the fans to be advantageously utilized.

The attempt must not be made to put more air through existing boilers by running the fans a great deal faster, because the power consumed will increase far faster than the above calculations estimate. New fans and engines must usually be installed of sufficiently larger size to supply the larger quantities of air at as high an efficiency, if not higher.

As has already been suggested, one way of reducing the work required from the fan in the case of doubling the capacity of the boiler is to increase the grate surface, so as to avoid a high increase of pressure drop through the fuel bed, increasing materially only the pressure drop through the boiler proper. A low pressure drop through the fuel bed would also insure better combustion of the fine particles of coal which would be carried out of the stack unburned if high gas velocities through the fuel bed were employed, the high velocities being obtained by high pressure drops.

This last method is being successfully used by H. G. Stott and W. S. Findley, of the Interborough Rapid Transit Company, New York City. They have recently installed an extra Roney stoker under the rear end of each of several Babcock & Wilcox boilers, with the result that the amount of steam produced was nearly doubled, the combined efficiency of the boiler and furnace dropping only about 3 per cent. A complete description of the outfits and the results is given in a paper read by Walter S. Findley, Jr., before the American Institute of Electrical Engineers in December, 1907.

In this case the pressure drop through the fuel bed was the same as with the single stoker, or perhaps decreased slightly. Of course, the pressure drop through the boiler proper increased considerably. An electrical engineer would say that the above experimenters put two fuel beds in parallel and with the same potential drop obtained twice the current (weight of gases).

The same result could have been obtained by thickening somewhat the fuel bed on the single stoker and increasing the pressure drop through it, in which case the electrical engineer would say that the experimenters put two fuel beds in series and by increasing the drop of potential obtained twice the current (twice the weight of gases). The method of increasing the grate area is a promising one because it requires less work from the fans; it is especially to be preferred in those cases where there is a high percentage of slack in the coal, as already explained.

The figures and principles derived from the experiments and tests presented in this bulletin may not be applicable directly to special problems; they suggest methods by which each problem can be studied and its successful solution brought about. Further experiments with laboratory apparatus, as well as with hot fuel beds, are desirable before more accurate figures can be given. The Geological Survey contemplates the making of such experiments in the near future, the results to be worked up and published in the next bulletin on "Drafts."

Electric Annealing Furnace.

For annealing and hardening it is of great importance to have an absolutely uniform temperature in the furnace and to be able to adjust the temperature at will and exactly. The material to be tempered must be heated equally and evenly so as to prevent any possibility of strain. Overheating often burns off sharp edges and coils.

During the past few years an electric furnace of very simple construction has been developed which fulfills all these requirements. Descriptions of this furnace as built in Europe were given in our Vol. IV, page 667, Vol. V, page 428, and Vol. VI, page 410.

The furnace has now been placed on the market in this country by the General Electric Company, after having gone through a thorough development and extensive tests in their Schenectady works. From an article by Mr. J. E. Kearns, of the power and mining department of the General Electric Company, in the December issue of the *General Electric Review*, we gather the following details:

In this new furnace metallic salts are reduced to a liquid state by means of electricity. As soon as they reach a liquid condition the temperature can readily be regulated by adjusting the current through the bath, a fact which enables the operator to secure any temperature from 250 to 1350 degrees Centigrade.

FIG. 1.—ELECTRIC ANNEALING FURNACE AND REGULATING TRANSFORMER.

This temperature will remain uniform throughout the bath except at the surface, where, due to radiation, it is slightly lower. But this applies only to a depth of about 0.6 to 0.75 inch.

Fig. 1 shows the furnace outfit as it is installed in the die department of the Schenectady works, where it has been in practical service for several months.

The outfit consists of the furnace, with its hood suspended from above; the regulating transformer, with regulating switch connected to the primary coil; the switchboard, which contains the necessary ammeter and voltmeter, and the incoming line with fuses and throw-over switch connected to the secondary winding of the transformer. The regulating switch is provided with a sufficient number of contact points to insure almost any desired temperature from 250 to 1350 degrees Centigrade.

The furnaces, the general plans and section of which are shown herein, consist of a fire clay crucible surrounded by an insulating material, usually of asbestos, which rests in a fireclay box, all being held in by an iron supporting case. Two suitable electrodes are placed on each side of the crucible and are in direct contact with the metal bath at all times.

To start up the furnace all that is necessary is to place some of the old broken flux between the electrodes and cover this with a little barium chloride, after which a small piece of

[illegible] directly against one of the electrodes by the [illegible] produces an electric arc, and in a remarkably short time the solid mass is converted into a molten condition.

After the bath has reached its proper temperature, that portion of the material which is to be hardened is placed entirely in the liquid bath and is allowed to remain there until it attains the same color as the bath, when it is removed and placed in water or oil, as required, to temper it. It can easily be seen that by this method of heating there is no chance for oxidiza-

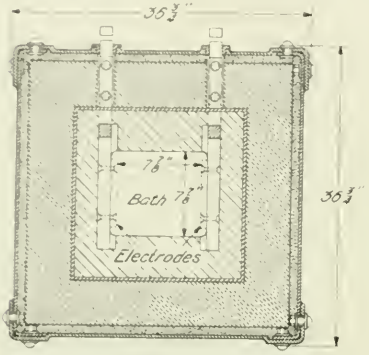


FIG. 2.—SECTIONAL PLAN OF FURNACE.

tion, for the material while heating does not come in contact with the air. Further, all parts are subject to the same amount of heat at all times. Before putting the material to be hardened in the liquid bath it is necessary to place it in a small oven above the furnace or near the bath so as to heat it slightly, because the immersing of the cold steel in the hot bath would strain it.

The bath for hardening or annealing completely fills the crucible, and usually consists of properly proportioned parts of barium chloride and potassium chloride, the correct proportion of either depending upon the material to be hardened. For ordinary good steel the Schenectady factory is using a bath of 50 per cent barium chloride and 50 per cent potassium chloride,

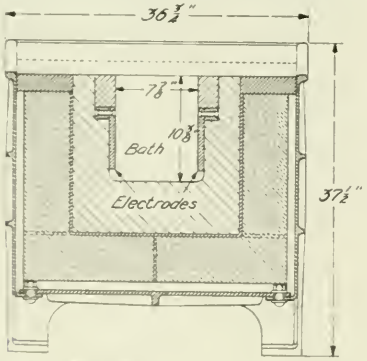


FIG. 3.—SECTIONAL ELEVATION OF FURNACE.

the amount of either being varied for raising or lowering the temperature. The more pure barium is used the higher the temperature, and the more potassium chloride is used the lower the temperature. For this class of steel a temperature of about 850 degrees Centigrade is required.

For high speed steel where a very high temperature is required (about 1350 degrees Centigrade), the bath consists only of pure barium chloride.

For temperatures below 700 degrees Centigrade pure sodium nitrate is used, and sometimes a mixture of sodium nitrate with potassium chloride.

In addition to hardening, the furnace may be used for softening tempered steel. For this process the liquid bath is kept at a temperature of about 250 degrees Centigrade. As in hardening, this method is far superior to the oil bath, because of the careful temperature regulation obtainable, which allows the tempering colors to appear gradually.

Some comparative tests were made with this electric furnace and with a gas furnace for hardening 100 milling cutters. The total cost with the gas furnace was $19.90, with the electric furnace $0.85. The cost of gas was $10.30 (1,000 cubic feet 80 cents), against a cost of electrical energy of $4.80 (2.4 cents per kw-hour). The wages were five times greater with the gas furnace than with the electric furnace, because the operation lasts five times longer with the gas furnace.

Upon further comparison of the electric furnace with the more common lead bath or cyanide process, the former will be found very much more efficient, from the fact that the metallic salts of the electric bath have no effect on the composition of the steel, and the operator never comes in contact with dangerous fumes, such as are given off by the cyanide bath. One of the most valuable attributes of the electric furnace is the fact that there is practically no danger from fire, inasmuch as its outer walls are never hot; in fact, when the bath has a temperature of 1300 degrees Centigrade, the hand can be placed

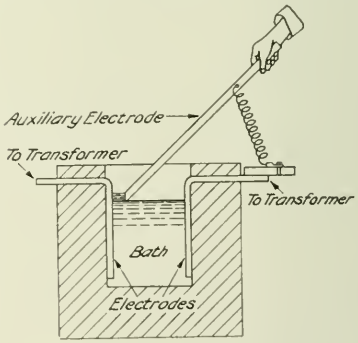


FIG. 4.—METHOD OF STARTING FURNACE.

on the outside of the furnace without being burned. A still further consideration is that the cooling bath may be placed close to the furnace, thus reducing to a minimum the time required to remove the material from the furnace and cool it.

Mr. Kearns thinks that this furnace, due to its high efficiency and its ability to anneal finished articles and leave them looking nearly as bright as when they leave the emery wheel, is bound to replace almost every other type of furnace that is called upon to meet the requirements in the tempering of dies and other steel parts used in the manufacture of the following: Machine tools, automobiles, razors, knives, firearms, files, jewelry, fine instruments, all classes of steel, chisels, twist drills, torpedo shell points, etc.

Notes.

American Electrochemical Society.—The following gentlemen were elected members at the November and December meetings of the Board of Directors: William L. Wilson, Chicago, Ill.; John W. Hulbert, Jr., Auburn, N. Y.; C. G. Seymour Bagot, Heriot Bay, British Columbia, Canada; Frank S. Washburn, Nashville, Tenn.; Dexter Edge, Wilkinsburg, Pa.; John T. Fuller, Plant City, Fla.; W. N. McAnge, Jr., Jackson, Tenn.; L. C. Tomlinson, Minneapolis, Minn.; Henri Aubry, Savoy, France; Alfred Dapples, Aguila, Italy; Frederick Von

Bidder, Holcomb Rock, Va.; Fred. W. Hersey, Loughborough, Eng.; Edward P. Hyde, Cleveland, Ohio; Leo Frank Guttman, New York City; Lewis Joseph Heizmann, Reading, Pa.; Stanley S. Seyfert, South Bethlehem, Pa.; Ezechiel Weintraub, West Lynn, Mass.; Charles L. Parsons, Durham, N. H.; Erik Cornelius, Trollhattan, Sweden; Olof Teodor Akerberg, Dalsland, Sweden; John W. Turpentine, Middletown, Conn.; Fred L. Collins, Chicago, Ill.; F. D. Crane, Montclair, N. J.; Samuel M. Kier, Pittsburgh, Pa.; A. H. Woodwell, Spokane, Wash.; Clifford D. Babcock, New York City; Robert Hunt Pierce, 839 Monadnock Building, Chicago, Ill.; Vernon G. Converse, Niagara Falls, N. Y.; Alan E. Flowers, Columbia, Mo.; Clement Alfred Smith, Santiago de Chile, S. A.; Edward C. Stover, Trenton, N. J.; Clarence W. Marsh, Niagara Falls, N. Y.; Edward Schildhauer, Culebra, Canal Zone, Panama; William Corin, Sydney, N. S. W., Australia; William Thomas Taylor, Baramulla, Kashmir, India; Ray L. Stinchfield, Washington, D. C.; Alfred Sang, Pittsburgh, Pa.; Hascal A. Hogel, Boston, Mass.; Samuel Hyam, Brooklyn, N. Y.; Rudolf Hoffman, Clausthal, Germany; Frederick J. Mayer, New York City.

Hydrogen for Balloons.—The Chemische Fabrik Griesheim-Elektron (best known by their diaphragm process for electrolysis of sodium chloride) are reported to be erecting a hydrogen plant for filling balloons. The gasometer is to have a capacity of 1,500 cubic meters, and the gas is to be obtained by water electrolysis.

The Rockwell Furnace Company, 26 Cortlandt Street, New York, has secured the services of Mr. Arthur L. Stevens, the well-known industrial and furnace engineer. Mr. Stevens has given much attention to the metallurgical field, especially in connection with oil and gas furnaces, and his aim will be to follow up their work in the line of economical, accurate and controllable temperature furnaces for industrial purposes, which the Rockwell Furnace Company are putting on the market.

Perkin Medal.—At the meeting of the New York section of the Society of Chemical Industry, on Jan. 22, the Perkin Medal was to be presented to Dr. Arno Behr for his contributions to the chemistry of the glucose industry. Dr. C. F. Chandler made the address of presentation and Dr. T. B. Wagner made the main speech of the evening on "The Great American Industry of Corn Products." Dr. Behr was not present. Dr. W. H. Nichols, president of the General Chemical Company, accepted the medal on Dr. Behr's behalf.

Personal.

Prof. **F. W. Harbord**, consulting metallurgist and analytical chemist of London, has entered into partnership with Mr EDWARD RILEY, metallurgical and consulting chemist, also of London. The two businesses have been amalgamated under the style of Edward Riley & Harbord. Mr. Harbord will undertake all consulting work and continue to give his personal attention to the analytical work at his laboratory at 16 Victoria Street, Westminster. Mr. F. J. Bolt, who has been with Mr. Riley for thirty years, has joined the firm and continues to have charge of the laboratory at Finsbury Square.

Mr. R. Livingston Fernbach has established offices as consulting chemist and engineer at 97 to 101 Warren Street, New York City, with laboratories at Brooklyn, Boston and Montreal. The personnel of his staff consists exclusively of experts and the organization is such as to enable Mr. Fernbach to assume contracts for factory construction in its entirety. The work covered by him includes the majority of manufacturing industries which have organic chemistry for their theoretical basis, to wit: starch, wall paper, textile industries, oils, glue, etc. In connection with his department of mines and metals it is interesting to note that those who do this work are employed by the Canadian Government, ensuring his clients of unbiased reports. Mr. Fernbach's personal work lies not so much in the laboratory as in the mills. Mr. Fernbach's staff consists of 20 members.

Digest of U. S. Patents

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC FURNACES (*Continued*).

583,249, May 25, 1897, Alfred H. Cowles, of Cleveland, Ohio. Resistance type. The furnace is a heavy pot of carbon surrounded by a water-jacket and constituting one electrode. The other electrode is a depending carbon rod having a water cooled holder. Horizontal water-jacketed gas pipes open into the lower end of the furnace chamber at opposite sides, and are connected through a reversing valve respectively to a source of combustible gas and air and to a discharge pipe. The passages leading through the side walls of the chamber to the gas pipes are filled with broken carbon. In operation, the furnace chamber is filled with a mixture of ore and carbon, or ore alone, which is covered at the top with a layer of fine carbon; or the top of the chamber may be sealed. The furnace is heated up to the working temperature by means of an electric current, primarily one producing a field of incandescence, and a mixture of gas and air is supplied to the lower part of the chamber through one of the pipes, burning in the interstices of the ore body. The products of combustion escape through and heat the broken carbon in the other horizontal passage. The reversing valve is then shifted, whereupon the mixture of gas and air enters through the heated body of broken carbon, acting as a regenerator, while the products of combustion escape through the carbon in the other horizontal passage, heating it. The gas flow being successively reversed, the entering mixture of gas and air is heated hotter and hotter, supplementing the electric heat both by combustion and by the recovered waste heat. Particles of soot, dust and sublimate matter picked up by the entering gas mixture are carried inward to the zone of reduction. The region of highest heat (barring an arc center) shifts laterally back and forth across the furnace chamber.

583,250, May 25, 1897. Alfred H. Cowles, of Cleveland, Ohio. Resistance type. This furnace is similar to that of the preceding patent. The chamber may be filled with a charge of broken coke. The furnace may be used to treat gases, for example, the waste gases from electric furnaces, for the production of an illuminating or heating gas.

583,618. June 1, 1897, H. Eldridge, G. H. Wright and D. J. Clark, of Galveston, Tex.

Arc type. Vacuum furnace for the reduction of ores, fusion of metals and manufacture of alloys. The furnace is a vertical cylinder of firebrick having a hinged two-part bottom of metal covered with carbon. The sidewalls are lined with carbon. The top is closed by a metal hood, the lower edge of which enters a seal of sand. The bottom of the vertical walls is supported in a pit and surrounded by sand. The carbon lining and hearth have cathode connections. The anode is a depending adjustable tube consisting of vertical carbon bars, suspended by rods passing through stuffing boxes in the cover. A gas escape and exhaust pipe leads from the hood through the side wall of the chamber. The top has a peep-hole, closed by a mica plate. In operation, the anode is lowered until an arc springs between its lowed end and the cathode bottom. It is then slowly raised until the arc jumps between the side of the anode and the carbon lining, after which the arc travels up and down. The fused metal or substance is withdrawn through a tap hole and the slag is dumped by allowing the hinged bottom sections to drop.

583,936. June 8, 1897, Edgar F. Price, of Niagara Falls, N. Y.

Arc type. The furnace is especially designed for the production of calcium carbide, and has a chamber in the form of a trough, with an inclined hearth constituting one electrode. The hearth consists of carbon supported in a cast-iron bedplate and is adjustable to vary its inclination. A longitudinal series of depending carbon bars serves as the other electrode. A water-cooled feed hopper surrounds three sides of the chamber, and

may consist of two or four hollow iron sections, each having water pipes. The front wall has a tap hole delivering into a fixed receiving chamber. The lower end of the water cooled hearth extends downward toward the hearth, and the space between it and the side walls constitute a flue for leading the waste gases to a vertical stack. This stack has alternating inclined baffle plates for collecting and delivering solid particles which collect. Stirring arms carried by a movable chain extend downward toward the zone of reduction. The depending electrodes are electromagnetically adjusted. The connection for each carbon bar is a copper plug which is screwed into the upper end of the carbon and into a metal head to which the electric conductor is clamped.

NEW BOOKS.

Laboratory Guide of Industrial Chemistry. By Allen Rogers. 167 pages. Bound in cloth. Price, $1.50. New York: D. Van Nostrand Co.

Recent Advances in Organic Chemistry. By A. W. Stewart. (With an introduction by K. Norman Collie.) 311 pages, bound in cloth. Price, $2.50 net. New York: Longmans, Green & Co.

First Principles of Chemical Theory. By C. H. Matthewson. 130 pages, bound in cloth. Price, $1 net. New York: John Wiley & Sons.

Electrometallurgy. By J. B. C. Kershaw. Bound in cloth. Price, $2 net. New York: D. Van Nostrand Co.

Practical Sheet and Plate Metal Work. By Evan A. Atkins. 491 pages, over 100 illustrations. Bound in cloth. Price, $2 net. New York City: Macmillan Co.

Glass Manufacture. By Walter Rosenhain. 264 pages, illustrations. Bound in cloth. Price, $2 net. New York: D. Van Nostrand Co.

Manual of Reinforced Concrete and Concrete Block Construction. By C. F. Marsh and W. Dunn. 290 pages, illustrated. Price, $2.50 net. New York: Engineering News.

A Handbook for Cement Workers. By Frank B. Gatehouse. 142 pages, illustrated. Bound in cloth. Price, $1.75 net. Philadelphia: Lippincott Co.

The Gases in Rocks. By Rollin T. Chamberlin. 80 pages. paper binding. Price, 50 cents. Washington, D. C.: Carnegie Institution.

Natural Sources of Water. By Rob. S. Hall. Bound in cloth. Price, $2 net. New York: D. Van Nostrand Co.

The Elementary Theory of Direct-Current Dynamo Electric Machinery. By C. E. Ashford and E. W. E. Kempson. 120 pages, bound in cloth. Price, $1 net. New York: Putnam.

Alternating-Current Machines. (Being the second volume of Dynamo-Electric Machinery, Its Construction, Design and Operation.) By Mason Hobart, S. Sheldon and Erich Hausmann. 364 pages, illustrated. Bound in cloth. Price, $2.50 net. New York: D. Van Nostrand Co.

BOOK REVIEWS.

A Text-Book of Physics. By A. Wilmer Duff. 8vo. xi + 671 pages. Cloth. Price, $2.75 net. Philadelphia: P. Blakiston's Son & Co., 1908.

This book represents a new departure in the writing of a text-book of physics for colleges, for it is the outcome of the joint work of seven professors of physics of prominent universities and technical schools.

The book is divided into seven parts, which are as follows: Mechanics and properties of matter, 177 pages, by A. Wilmer Duff; heat, 102 pages, by Karl E. Guthe; wave motion and sound, 45 pages, by William P. Hallock; light, 45 pages, by E. Percival Lewis; electricity and magnetism, 106 pages, by Arthur W. Goodspeed; electromagnetic induction, 47 pages, by Albert P. Carman; conduction of electricity through gases and radioactivity, 35 pages, by R. K. McClung. The different parts of the work were read and revised by each of the collaborators, and finally compiled by the editor, Dr. Duff.

The practice of having several persons take part in writing a comprehensive treatise on scientific subjects is common and needs no defense. On the other hand, the production of a college text by seven men is quite a novel undertaking, and the task accomplished by the editor in getting the material into compact and coherent form was certainly not an easy one. While it is true that different chapters of a book may be written better by men who have specialized in certain fields, there is nevertheless danger in adopting this method in writing a college text that the various parts become somewhat unbalanced as compared with one another, and that the book as a whole become too voluminous. In the present case it is moreover somewhat difficult to see why three different collaborators should have been required to write what is necessary to be presented on electrical phenomena in a college text-book on physics.

The book is clearly written, though to be sure this is not true to the same degree of its several parts. All of the chapters except the fifth and seventh end with a series of problems which will no doubt be very helpful to both student and teacher. The work as a whole seems rather bulky for a college text considering the amount of time that the average college student has to spend on the subject of physics.

While it is easier to omit things from a text than to amplify it, it is doubtless best to present only the salient points (which should be most carefully selected) in such a way as to meet the needs of the student.

It will be of interest to watch the success of this book in practice. As a work of reference in connection with smaller books it will no doubt be of service; whether it will prove equally useful as a text in the classroom the future will demonstrate. The book is well printed and solidly bound in cloth.

* * *

The Mechanical Appliances of the Chemical and Metallurgical Industries. By Oskar Nagel, Ph.D. 311 pages, 292 illustrations. Price, $2 net. New York: The Author.

"The aim of this book is to clear up ideas regarding the mechanical appliances used in the chemical and metallurgical industries, to expose the real importance of the machines used in the various processes and to get rid of the obscurities prevailing at present in these matters. It is hoped that this treatise will fill a deeply felt want, as there is only one book on the market along similar lines, viz.: Parnicke's well-known German work."

The book consists of 15 chapters dealing with the following subjects: General (covering, packing, expansion joints, valves, steam traps). Steam and water power. Gas power. Electric power. Transportation of solids (elevators, conveyors, etc.). Transportation of liquids (pumps, syphons, etc.). Transportation of gases (blowers, ventilators, etc.). Grinding. Mixing machines. Firing and furnaces. Separating.. Purification of gases. Evaporating, distilling and condensing. Drying appliances. Measurement of temperature. An address by Dr. Oscar Guttmann on the works chemist as engineer is given in an appendix.

The book is chiefly descriptive and covers the chemical engineering appliances and machines now on the market in this country in a fairly complete manner. The descriptions are brief and to the point.

The merely descriptive character of the book is a point of strength, but also results in a certain weakness, as one might wish to see the underlying physico-chemical principles more thoroughly explained and discussed in various chapters.

However, the book as it is, is the only work of its kind in English and will be welcome to all who have to use chemical engineering machines and appliances. The price of the book is surprisingly low.

Electrochemical and Metallurgical Industry

VOL. VII. NEW YORK, MARCH, 1909 No. 3

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH. D.....*President*
E. F. ROEBER, PH. D.....*Editor and Secretary*
C. E. WHITTLESEY.....*Treasurer*

Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, MARCH, 1909.

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The Adoption of the Heroult Furnace by the United States Steel Corporation.

The decision of the United States Steel Corporation to adopt the Héroult electric furnace for steel refining at two of its plants is a matter of more than passing interest and is likely to result in developments of considerable importance. Details of the plans of the Steel Corporation will be found on page 104 of this issue. Here we shall try to emphasize only the points of broadest significance. First, about the size of the furnaces. The largest Heroult steel furnaces installed in the past have a capacity of five tons. The largest steel furnace built anywhere so far (one of the Rocchling-Rodenhauser type in Germany) has a capacity of eight tons. The Héroult furnaces of the Steel Corporation will have a capacity of 15 tons. And admittedly this is only a beginning, and the erection of 30-ton furnaces is contemplated when sufficient experience has been gained with the 15-ton size. The development is characteristically American. Our steel masters have patiently waited till all the little details and problems had been worked out in Europe and the tedious experimental stage was passed. Now they are going into the matter not in a half-hearted way, but on a scale untried in Europe. The United States Steel Corporation becomes the daring pioneer of the *big* electric steel furnace.

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The second point of decided novelty is the purpose for which the steel refined in the electric furnace is intended to be used. In the two American steel works in Syracuse and McKeesport where Héroult furnaces have been installed in the past, the object has been to replace the crucible process by the electric furnace, to make special steels electrically. At South Chicago and at Worcester the Héroult furnace enters into a wider field, as the steel is intended specially for rails and wire. The manufacture of tubes and other products from electric steel is likely to follow. The Steel Corporation thus becomes the pioneer of electric refining of steel for large tonnage products. The development was clearly foreseen by Dr. Héroult in the paper which he presented at the International Electrical Congress in St. Louis in 1904. This may be mentioned as interesting evidence that Dr. Héroult combines with his eminent qualities as a chemist and engineer a most remarkably sound judgment of industrial evolution. After having pointed out that with the advent of electric steel refining there would be in future no excuse for not making steel free from impurities, such as sulphur and phosphorus, he concluded that he was far from predicting that the electric furnace process would supersede the old metallurgy of steel, "but it will and must cause a revolution, so far as the quality of the metal used in the industries is concerned." This is exactly what now takes place, and the Steel Corporation has become the leader in this peaceful revolution.

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It is to be sincerely hoped that the satisfactory solution of the rail problem, which has become more troublesome from year to

ver will be the first important practical result of this develop- ment. Steel men have in the last years inclined to favor strongly the open-hearth as against the converter, and more than once it has been prophesied that the converter was doomed. The combination of the Bessemer converter with the Héroult electric furnace as it will be carried out at South Chicago for rail making, changes the situation completely. Far from becoming a competitor or enemy to the old metallurgy of steel, the electric steel-refining furnace really seems to be destined to give the converter a new lease of life. By the combination of Bessemer converter and electric furnace it is possible to make steel superior in quality to open-hearth, and it is even a possibility that under certain conditions it may be found cheaper. The developments of the future will decide this question. The combination of the electric furnace with the open-hearth at Worcester is not less interesting. The result will be again a decided improvement in the quality of metal. The electric furnace permits the production of a thoroughly deoxidized metal, free from slag and other impurities, with the impurities as low as desired, say phosphorus below 0.01 and sulphur below 0.01 and there can be no doubt that having adopted electric refining the United States Steel Corporation will make the widest and best use of its possibilities.

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What is really at the bottom of the technical possibilities of the electric furnace? Two things are of chief importance. First, the reducing atmosphere, in thorough contradistinction to ordinary metallurgical practice, where heat production is accompanied by oxidation as in the open-hearth with oxygen as active element. The reducing atmosphere of the electric furnace makes it possible to thoroughly deoxidize the metal. The second point of importance is the old well-known feature of electric furnaces—the possibility of producing higher temperatures than can be obtained in ordinary metallurgical furnaces. This is the chief reason of the possibility to thoroughly desulphurize the metal. The higher temperature permits the use of a more basic slag, and, therefore, a much better desulphurization by the same reaction by which sulphur is removed in the basic open-hearth process. But this is not all. Careful investigations of the process by which sulphur is removed from steel in the electric furnace point to the fact that we have here to do with new chemical reactions which are impossible at the lower temperatures of ordinary metallurgical furnaces. The sulphur is removed in the Héroult furnace in form of calcium sulphide, and the formation of calcium carbide appears to play a part in this reaction—a fact which directly indicates the absolute necessity of a very high temperature. The paper by Dr. Amberg, published in this issue, is interesting in this connection.

Alloys.

Mr. David H. Browne who in the past has been deeply concerned in the separation of nickel and copper from copper-nickel ores, contributes to our present issue an interesting resume statement of the remarkable properties of Monel metal, a nickel-copper alloy about which much has been heard during the past few years. That it should be possible to prepare from nickel and copper an alloy with about 25 per cent greater tensile strength and 50 per cent greater elastic limit than the best rolled steel, with the additional quality of incorrodibility, is something as remarkable and unexpected as was Heusler's discovery that it is possible to make magnetic alloys from unmagnetic metals. But these two discoveries must have a decidedly stimulating and encouraging effect, as they show the unlimited possibilities of experimental researches on alloys.

"The Old Order Passeth."

For many years the visitor to the "Argo" plant of the Boston & Colorado Smelting Co. was shown courteously the original Brown straight-line roasting furnace, the Pearce turret roaster, the large reverberatory copper furnaces, and the intricacies of the Ziervogel process. But he was denied admission to the gold refinery, where the gold was separated from the copper and refined by furnace methods. Lately, the refinery was burned down, and as the electrolytic refining of copper has developed into a much more efficient process for the separation of gold and silver from copper than the Pearce process, the Argo refinery will probably never be rebuilt. As the reason for secrecy no longer exists, Prof. Pearce's son, Mr. Harold Pearce, has presented a paper describing his father's process at the New Haven meeting of the American Institute of Mining Engineers. It is in the nature of an obituary of a metallurgical process which has lived a long life of usefulness.

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It was generally apprehended by practical smelting men that two general reactions were used. The first was presumed to be the formation of the copper bottoms out of copper matte as it was well known that metallic copper so formed will concentrate with it nearly all the gold. The second reaction was guessed by Mr. H. W. Hixon to be the smelting of these copper bottoms with pyritic ore and in Chapter II of his "Notes on Lead and Copper Smelting" he describes this reaction. The Pearce process now proves to be exactly what Mr. Hixon had conjectured, though, of course, modifications were made in its practical working. The Pearce gold process, briefly described, consisted of the formation of "copper bottoms" containing 100 oz. to 200 oz. of gold, while the matte formed with it contains only one-fifth of an ounce of gold—a sharp separation. This metal is granulated and melted with iron pyrites in a reverberatory furnace. Another "copper bottom" is made concentrating the gold further. The operation depends on the fact that the solubility of gold in metallic copper is far greater than its solubility in copper matte. Three "granulations" and "strippings" with pyrites were made, till finally a rich alloy containing 10 to 20 per cent gold was made. This was sent to the refinery where the same operation was repeated two or three times, but in crucibles, instead of in a reverberatory furnace. Finally gold bullion, 920 fine, was produced, which could be sold to the United States Mint. The recovery of gold varied, but was as low as 98 per cent and as high as 100 per cent. Epitomized the process depended on the "distribution coefficient" of the relative solubilities of gold in metallic copper and copper-iron sulphide and the ability to successively increase the mass of copper-iron sulphide by the addition of iron bisulphide.

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One of the advantages of the process was that it required only simple and cheap apparatus. It was designed for the neces-

sity which presented itself of treating cheaply copper ores rich in the precious metals and the "Argo" smelting plant eventually became more of a gold plant than a copper plant. The fact that no expensive apparatus was needed reminds us of that very efficient process for separating copper-nickel matte by smelting with salt-cake. This process depends on the difference of the solubility of two substances in one solvent (whereas the Pearce process depends on the difference of the solubility of one solute in two solvents) and is commercially efficient because of simple form of treatment. The Pearce gold process produced nearly 1,600,000 oz. of gold in the 30 years of its existence. It had a profound influence on the mining of ores in Colorado, as it gave a market for ores which were hard to treat otherwise. Its history reflects great credit on its inventor, Prof. Richard Pearce, who is a Nestor of the metallurgical profession. It is no disgrace, either, for it to retire from the field in favor of the electrolytic copper refining process.

A Practical Point on the Use of Pyrometers.

Compared with the simple mercury thermometer, electric pyrometers, whether of the resistance or of the thermo-electric type, have the disadvantage of not being a self-contained unit. They consist of three distinct parts: at one end, where the temperature is to be determined, we have the resistance wire or the thermocouple; at the other end, where the reading or the record is taken, we have the indicator or recorder; and as connection between both ends we have the connecting wires. Manufacturers of pyrometers are now able to make the bulbs containing the resistance wire or the thermo-element, as well as the indicating and recording instruments, fully reliable under the difficult conditions which prevail in the workshops. But the fact that there must be connecting wires constitutes a certain inherent weakness from a practical standpoint in more than one respect. A peculiar mistake which users of thermo-electric pyrometers are liable to make and which, as a matter of fact, is made more often than would seem probable, is discussed in an article by Mr. Wilson in our present issue. The mistake is the connection of the thermocouple of a high-resistance pyrometer with the indicator of a low-resistance pyrometer. Why this is wrong Mr. Wilson shows very clearly. How such mistakes can happen is also clear. Buyers of a platinum thermocouple get a certificate from the Bureau of Standards giving the relation between temperature and millivolts. Then they find in the catalog of an electric instrument maker a millivoltmeter that takes their fancy, and they order it without stating for what purpose and without thinking whether it will suit their thermocouple. Mr. Wilson's article deserves the fullest attention of users of thermocouples. It will be seen that there is absolutely no mystery in this matter. To make such a mistake as mentioned above is about of the same order of engineering thoughtfulness as to connect an alternating-current induction motor to a direct-current network or to couple a narrow-gauge engine with a standard-gauge car, trying to run both on two rails.

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A second point of weakness due to the connecting wires was emphasized by Dr. Northrup in his recent paper before the American Institute of Chemical Engineers and published in our February issue. It is that people are only too liable to be simply careless in making the wire connections. As Dr. Northrup pointed out, if a mechanical engineer wishes to transmit 10 hp across a factory, he puts up in a substantial manner a line of shafting and it stays in order. An electrical engineer could carry the same power across the factory with a single wire the diameter of a pin, laid on the floor. This is a serious source of temptation to put up flimsy, uncertain wiring. If something goes wrong, as it surely will, it is then easy to kick that electrical installations cannot be relied upon like mechanical installations. If the 10 hp were carried in a lead-encased cable, as substantially supported as the shafting, the electrical transmission would remain in operation when a line of shafting and belts had rusted and rotted into uselessness.

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At first glance it might seem that the optical pyrometer and the radiation pyrometer are free from this source of weakness, as the measurement is here made from a distance. But in reality the radiation pyrometer employs a thermocouple on which the heat rays are concentrated so that the radiation pyrometer is really an elaboration of the thermo-electric pyrometer. On the other hand, in the optical pyrometer we have a luminous source which must be kept constant, but which is liable to change by the battery running down or the filament changing its efficiency. Further, the lenses and prisms must be kept clean; they play a rôle somewhat analogous to the connecting leads in an electric pyrometer. These remarks are not made to discourage in the slightest degree the use of pyrometers. Fortunately, people can no longer be discouraged now. The danger is now at the other extreme. People expect too much from pyrometers. The way in which sometimes men are handling pyrometers makes it absolutely necessary to emphasize again and again that at least ordinary care and thoughtfulness are required in pyrometer installations. In spite of all progress that has been made in making pyrometers more reliable, stronger and better adapted to workshop conditions, yet absolutely foolproof they cannot be made.

The Reduction in the Price of Steel.

The reduction in prices of steel products which has been in progress since the decision of Feb. 18 to abandon the policy of maintaining former prices is likely in the long run to restore the industry to its former activity. It was not an easy task which a few men set for themselves towards the close of 1907, when it became evident that without intelligent direction the steel trade was likely to find itself in a worse panic than ever before in its history. The industry was subject to great dangers. Not only had capacity grown at an enormous rate, but there was a large amount of capacity just installed which was not really needed, and there was still more capacity on the way. The capacity was becoming unwieldy, even though no financial panic or industrial depression had intervened. In a period of three years of unexampled activity, when the problems of the trade were largely those of avoiding undue delay in the filling of orders, the usual spirit of moderation and conservatism had been lulled, and with the suddenly arising insufficiency of orders, complete demoralization threatened the industry. The industry was saved from demoralization through a campaign of education in co-operation and conservatism. On the surface it was a campaign to maintain prices, but it was

[illegible] methods from other operations in the [illegible] have had similar ends in view, and instead of merely [illegible] restraint which would leave sellers more prone [illegible] to cut prices when the restraint was removed, it [illegible] methods and principles the influence of which has [illegible] produced a moderation and conservatism in [illegible] prices, now that the market has officially [illegible] "open," which has surprised even the more [illegible] supporters of the campaign.

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[illegible] were necessary, and it is well at this time [illegible] the position which the iron trade found itself in at [illegible] of the panic of October, 1907. The need for restraint [illegible] arose largely from that panic: the trade had troubles [illegible] to meet through the remarkable and not altogether well-[illegible] burst of activity in new erection. Let us go back of [illegible] panic. In our issue of March, 1907, our report on the iron [illegible] market pointed out, in tabular form, by half years, the [illegible] in pig iron capacity which had been and were being [illegible] about through the completion of new furnaces. This [illegible] that while in 1902 "it taxed the resources of the industry to make 17,821,307 gross tons of pig iron, in 1906 25,307,191 tons had been made, and the prospects in March, 1907, were that 28,000,000 tons could be made in that year," and the report then remarked: "With the present trade outlook it is certain that no such tonnage can be absorbed." Those words were proved true, and they would have been true had there been no panic in October. It is true the industry did not stop its increasing production until the panic, for in the panic month of October it made more pig iron than in any previous month in its history. Nevertheless, the year's production was only 25,781,361 tons. With a few additional furnaces projected, the position to-day is that, with present new erection completed, the industry will have an annual producing capacity of not less than 32,500,000 tons. Our report in March, 1907, referred to the probability of a reaction in pig iron prices within a few months, but said: "It does not follow that a reaction in prices of finished steel products is probable, for the double reason that pig iron has reached a level out of all proportion with finished products, and prices of finished steel products are closely held. They were prevented from unduly advancing, and can within limits be prevented from declining." How closely finished steel prices were held, and how wide were the limits within which they could be kept from declining, market history [illegible] has plainly shown.

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With the maximum capacity in prospect, 32,500,000 tons of pig iron and commensurate capacity in steel making and rolling, when the greatest calendar year's pig iron production has been 25,781,361 tons, it is evident that in order to permit competition with wood and concrete, and for the encouragement of new uses and wider employment, a reduction in selling prices was clearly dictated. Had capacity not been swelled far beyond the requirements even of the high-pressure period which culminated in 1907, a revision would doubtless have been necessary, but with the added load the necessity was made the more imperative. The reductions in prices are by no means a dead loss. There are compensations which may make up all the loss, and more, too. In the first place, a reduction in wage rates, where they were unduly advanced through the abnormal high pressure conditions in the recent active period, is regarded as certain within the near future. Then other economies will be introduced with more energy as the necessity has been made more apparent, while with increased tonnage operating costs should be reduced very materially. In some respects the steel trade was less well prepared than ever before for a period of slack operation, due to its having on its hands large mills built only for tonnage, and taking the place of what under former practice would have been groups of smaller mills, some of which could have been operated and others closed. Then the large continuous mills have involved heavy charges for roll changes, when specifications were of the mixed character prevailing last year. That larger tonnages will come in the measurably near future is not to be doubted, and it may be sooner than is now generally expected that full employment will be given the industry, even though it has a capacity fully a fourth larger than has ever been engaged in a calendar year.

Socialism and Social Efficiency.

It is perfectly true that on but few subjects is there any uniformity of opinion. And this heterogeneity is the spice of life. But of all complex subjects, to our mind, the relation of capital and labor is the most complex. Let the fact be granted that intelligently directed intelligent labor is the prime essential of success in manufacturing. Then it can be deduced that for the maximum of commercial efficiency the laborer should have reasonable hope, comfort, and a chance for the pursuit of happiness. Such ideal conditions rarely exist, and the complaint of their absence takes the form of discussions, pro and con, of the vast mass of vague doctrine that is circumscribed in literary fashion by the word "Socialism." Of the mass of seething literature that comes from the welter of arguments on this subject, the writings of two men, one brilliant yet visionary, the other cold, hard-headed, but warped in his views, have appeared. The protagonist of the socialists is Mr. H. G. Wells, who has mixed some common sense with his visions. The champion of the anti-socialists is Mr. W. H. Mallock, whose "Critical Examination of Socialism" is hailed with joy by the followers of the old English school of *laissez faire* economists. Both of these men cover a wide range of literary activity, for each is a philosopher, essayist and novelist, as well as a student of social evolution. Each attacks the subject according to his own bias. Wells minimizes the strength of modern society. Mallock minimizes the weakness of the reform impulse. To our mind, the truth lies between the extreme positions.

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Socialism is essentially a philosophy of discontent. Ninety-nine per cent of the socialists in America have some real or fancied grievance against society. The remaining 1 per cent have a lively and quick sympathy that extends their altruism so that it absorbs in the ego of the individual the woes of all the unfortunate. Things are queer and lopsided with man and there is a concentration of money-making and happiness-making abilities in the minority. This has always been so, but the flux of modern social and industrial evolution has aggra-

vated this lack of balance. Distribution of money and happiness is always unequal, and sometimes unjust. In modern times, the efficient man has become much more efficient and his coefficient of efficiency is multiplied by a vastly larger quantity, due to the fact that the industrial machine as well as industrial machinery has an immensely larger output. The growth of science has changed our way of looking at the world. The growth of applied science has changed our world. The modern business man is simply a glorified money-getting brain, and a brain that absorbs other brains, as the germ cell absorbs other inferior cells. Now, we believe that the doctrine of Gen. Francis A. Walker, who, let it be remembered, was the pioneer in technological education, and, to our minds, thus fittingly a political economist, is sound. In modern society the margin of superiority of one enterprise over another similarly located, depends on the entrepreneur whose intelligence directs the business. Assume three factories precisely the same as regards machinery, labor and location, each employing 100 men, and the first making a profit of $100 per year per man, and the second a profit of $200 per year per man, and the third has no margin after proper charges for interest, depreciation and insurance against business risks are deducted. The entrepreneur or owner-manager of the first makes $10,000 per year as his margin over the third factory, which, inefficiently managed, has no margin, while the manager of the second plant has a margin of $20,000 over the poorest plant. This is a bald and concrete statement of the simple facts.

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Now, we will assume that the number of employees is not 100, but 10,000. Then No. 2's differential advantage, assuming that his mind and capacity is of such a character as to permit of expansion, which is only an approximation to the truth, is $2,000,000 per year. These cold figures are, with proper corrections, the ideal expression of the reason why the modern captain of industry reaps profits out of all proportion to his father's profits. It is simply the logic of political economy. The discontented man may say no man should earn over $10,000 per year and this is a question of social ethics and not of political economy. With no small measure of truth the advocate of socialism affirms that success—the magic word of America—comes, not to the worthy planner and doer of big things, but to the shrewd and calculating financier who studies trade conditions and the sinister motives of humanity; in short, that "in business it is not the survival of the fittest, but the survival of the slickest." The alliterative aphorism is only too true in many cases.

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It is a fact that the trust when well operated is the most efficient instrument of production that the world has ever seen. The cost of production has been reduced, but the cost of retailing, or cost of secondary distribution, is exceedingly high and the means are inefficient. A small consumer buys in a small town in New York State from a hardware store 10 lb. of eight-penny wire nails for 50 cents. For this he pays 15 cents to the producer of steel for digging the ore out of the ground, mining and coking the coal, transporting ore, coke and limestone to the blast furnace, turning these into pig iron and slag, and making steel billets out of the pig iron. Certainly this is a very low figure considering all these laborious processes. Then he pays 4½ cents for the conversion of the steel into wire and from wire into nails and packing the nails into a keg. He pays the railroad 2 cents for transporting these nails to the place of consumption, finally he pays the retailer, assuming that the latter buys a carload, 28.5 cents for the privilege of going into his store and having the nails weighed out and wrapped up in a paper by a clerk with a pleasant smile, which smile he does not always get. Somehow or other, in spite of the great value to the nation of the body of retail merchants, the charge for retailing does not seem commensurate with the value of the service. On the other hand, the price of the producer is perfectly fair when regard is paid to the amount of labor and pains it has taken to make the nails. Summarizing the conclusions, let us say that the trust has solved the question of cheap production, but the future problem is cheap and efficient distribution.

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With regard to government operation of the public utilities socialism does not seem to promise much. Ninety per cent of the privately owned plants give efficient service to the consumer, while 90 per cent of the municipal plants give inefficient service. This is the judgment of a well-known public accountant. Managing and technical ability are not paid adequately, and, when not paid adequately, their work is not good. Hence, the consumer suffers in increased taxes or in poor service. For it is an axiom of political economy that the consumer in the last analysis pays the bill. Furthermore, as in any new development, such as a new smelting process, it is always well to see how the new proposal works on a small, practical scale. Many socialistic or communistic bodies have been formed, but all, measured by the standpoint of results, are miserable failures. Socialism even as modified by its latest and saner advocates and not as exemplified by the earliest advocates, whose methods were destructive rather than synthetic, takes little account of human weakness and human selfishness. Social reform will take quite a different course from the sweeping changes that the socialists demand. The problem of distribution can be solved by co-operative stores, intelligently managed. The partial amelioration of the working classes can be attained by cheap, fireproof, sanitary dwelling houses. Their modest happiness on the one day of leisure can be made at least possible by the revocation of ridiculous blue laws. The cost of living can be reduced by intensive cultivation of small family gardens by each working family. A graduated income and inheritance tax will give funds in the future, not so much, we hope, for mammoth battleships as for technical and trade schools. Better distribution of financial knowledge will improve the position of the small investor and extend his number and conserve his savings. As medical science more and more seems to rely on the powers of the human body to resist disease when nature is not restricted, so political science must turn to perfectly natural means for building up the political body, to trust in plain common-sense science rather than to the nostrums of the quack. Men and women separately and individually must learn the efficient way to live as well as the efficient way to make a living. The health of the political body depends on the health of its individual cells. Socialism complains that society is sick But social reform brings the invalid back to health.

New York City Proposed for the 1912 International Congress of Applied Chemistry.

In the past Paris, Berlin, Vienna, and Rome have enjoyed the privilege of entertaining the International Congress of Applied Chemistry. This spring it will meet in London. It is now proposed to issue an invitation to the London Congress to hold the next meeting, in the spring of 1912, in New York City.

A preliminary informal discussion had taken place on this project some time ago at the invitation of Dr. Chas. Baskerville. The first open meeting, called by the temporary committee for discussion of the project was held at the Chemists' Club, New York City, on February 20, Dr. Wm. H. Nichols being chairman and Dr. H. Schweitzer acting as secretary.

A motion of Dr. Bogert was carried, to the effect that it was the sense of the meeting that preparations should be made to issue the invitations. A general meeting of representatives of societies, universities and manufacturers will be called for April 3.

A committee was appointed to go to Washington to request Congress to give the required authority to the Secretary of State to issue the official invitation.

Niagara Falls Meeting American Electrochemical Society.

Very great interest is already manifested in the coming annual meeting of the American Electrochemical Society, to be held at Niagara Falls on May 6, 7 and 8.

Dr. E. G. Acheson, as president of the society, is endeavoring, together with all the Niagara Falls members, to make this convention a truly memorable one in every respect.

The society has grown wonderfully during the past year and the membership is about to pass the 1000 mark.

The whole first day of the convention is to be devoted to the electrometallurgy of iron and steel, and Messrs. FitzGerald and Bennie are endeavoring to arrange a most interesting program representative of the new industry. Papers are expected on all the important processes in this field. A paper on the Héroult steel process is expected from Mr. Robert Turnbull, Dr. Héroult's chief engineer. Dr. Girod has cabled from France that he will send a paper. So will Dr. Kjellin of Sweden and Mr. Gin of France. Papers are also expected from Mr. Stassano, Mr. Keller and others. Dr. Haanel has been invited to present a paper.

Aside from the preparations which are being made for the professional sessions, the social side is not being neglected. The "irrepressible Section Q" plans some marvelous entertainments, and headquarters will be at the Clifton Hotel, on the Canadian side.

The Heroult Furnace Adopted by the United States Steel Corporation.

The United States Steel Corporation has adopted the Héroult electric furnace and steel process. During the last two years an investigation of electric steel furnaces was made abroad by engineers of the Steel Corporation, and on the favorable reports received from these engineers and from the patent attorneys and experts, the board has now decided to appropriate the necessary funds at once.

For the present two electric Héroult furnaces, each of 15 tons' capacity, are to be installed, one at the South Chicago works of the Illinois Steel Company, and the other at the Washburn & Moen plant at Worcester of the American Steel & Wire Company.

At the South Chicago plant the Héroult furnace will be used for refining liquid steel taken from Bessemer converters to make a high-grade steel rail ("tool-steel rail") and high-grade steel axles and car wheels.

At the Worcester plant the Héroult furnace will be used for refining liquid steel taken for two 50-ton open-hearth furnaces to make high-grade wires (for instance, low-carbon telegraph wires) and other high-grade specialties.

Concerning the daily output of the 15-ton Héroult furnaces the estimates vary somewhat. *Iron Age* estimates an output of about 500 tons per 24 hours, but this seems high and is probably a misprint. If on the experience with former electric furnaces the complete time required for finishing one charge is taken as one hour, or an hour and a quarter (which is quite a conservative estimate), then the output of a 15-ton furnace in 24 hours is about 300 to 350 tons.

It is probable that another Héroult furnace of the same size will be installed at Homestead. It is contemplated to follow this up with the erection of 30-ton and probably even larger furnaces later on.

The construction of the furnaces at South Chicago and at Worcester will be vigorously pushed and both plants are expected to be running in about three months.

We comment on this development on page 99.

E. G. Acheson, D.Sc.

The University of Pittsburgh conferred on Mr. Edward G. Acheson, president of the International Acheson Graphite Company of Niagara Falls, N. Y., the degree of Doctor of Science on Friday, Feb. 12. The convocation was held in Carnegie Music Hall and was in commemoration of the birth of Abraham Lincoln and Charles Darwin. It was made memorable by the presence of Hon. James Schoolcraft Sherman, vice-president-elect. The degree of Doctor of Science was conferred upon Mr. Acheson in recognition of the fact that the many industrial and engineering successes he has scored are the results of his scientific research.

It is hardly necessary to refer here to Mr. Acheson's preeminence in electric furnace work and to the fact that Acheson graphite is used all the world over by electrochemical engineers. But Mr. Acheson's influence extends much beyond the purely electrochemical field and is felt in many industries. His work has added very materially to the world's wealth and will be of material assistance in the future conservation of our natural resources. This is particularly the case with lubricating oils, as his latest invention of "deflocculated graphite" and applying it to lubrication is esteemed and appreciated as a factor destined to largely conserve the world's supply of lubricants.

In many respects Mr. Acheson's work has been marvelous, for his success in making valuable new articles from commonplace raw materials has opened new possibilities in many fields, and by conferring on him the degree of D.Sc., the University of Pittsburgh has given honor where honor is due.

The Iron and Steel Market.

At a meeting of prominent officials of the United States Steel Corporation and most of the important outside steel producers, held in New York on the afternoon of Feb. 18, it was decided to declare an open market on all steel products with the exception of standard rails, each producer to find his own price.

This action was taken for several reasons. Immediately following the panic of October, 1907, an arrangement was made between the principal producers whereby they would interchange information freely and avoid naming new prices for their products. The object was to maintain profits, avoid demoralization in the market, protect jobbers and consumers as to the stocks they had on hand, and protect producers as to the large contracts they had on their books, prices upon which would have to be adjusted in case the open market declined.

In January moderate reductions were made in sheets and tin plates and early in June moderate reductions were made in other products, with the exception of standard rails. The immediate objects of this operation were accomplished, stocks

and contracts being protected. Another object, that of avoiding demoralization, was also accomplished, in a measure, even should the market be declared open, because during the period of 15 months in which conferences were held a feeling of confidence and desire for co-operation was developed and established, the effect of which bid fair to remain even should the market be declared open.

One object very distinctly failed of attainment, that of stimulating business and restoring the trade to its former tonnage basis. There was a more or less regular improvement in demand in 1908, particularly in the second half of the year, but in the new year the movement was in the opposite direction. It became increasingly certain that lower prices would have to be made, partly because some producers were cutting the established prices, but chiefly because it required a distinct incentive to bring out better orders.

The declaration of an "open market" was, of course, largely a matter of form. The majority of manufacturers wished to reduce prices, but did not wish to reduce them indefinitely, desiring to stop at the highest practicable point, and the notice given that reductions would be promptly met was expected to act as a brake and prevent the reductions proceeding too far.

The outcome has fully justified the expectations, while many have been surprised at the moderation displayed. One circumstance which contributed much to the orderliness of the readjustment was the fact that no large orders were pending. There was no incentive to name particularly low prices in order to secure special orders, and besides this the spirit of co-operation instilled in the past 15 months remained, whereby individual producers expect only to receive their share of the tonnage and do not wish to book a part of the proportion at an especially low price.

Within a couple of days after the market was declared open a stable level was found for plates, shapes and merchant steel bars, plates and shapes being at 1.30 cents a pound and steel bars at 1.20 cents a pound. The previous official prices had been 1.60 cents on plates and shapes and 1.40 cents on steel bars, the prices prior to the reductions of June, 1908, being 1.70 cents on plates and shapes and 1.60 cents on steel bars. A considerable portion of the total tonnage had been selling at less than the official prices, narrow plates being sold at 1.40 cents to 1.50 cents and shapes in some cases down to 1.25 cents, so that while the nominal reduction was $6 a net ton the actual reduction only averaged $4 or $5 a net ton. In bars, the 1.40-cent price had been subject to the regular concession of $1 a ton to large jobbers and some large manufacturers, while the new price of 1.20 cents is net to all interests, so that the bar reduction is $3 to $4 a ton.

The National Tube Company, Feb. 22, announced to its trade a reduction of five points in the official list, making the official discount 80 per cent off, in "jobbers' carloads." The actual prices are regularly an extra half-point and 5 per cent to large consumers and an extra point and 5 per cent to large jobbers, making the new inside prices 80½ and 5 and 81 and 5 off list. As the list averages about 10 cents a pound, a point is about $2 a net ton, and the total reduction is about $10 a net ton. Pipe prices had not been shaded, so that the actual market has declined by this amount. The prices had been particularly high, and the new price is no lower than prevailed from October, 1905, to October, 1906, a period of general prosperity. Through a succession of advances pipe had reached a point quite out of relation with other finished steel products.

The American Sheet & Tin Plate Company did not announce new prices on sheets and tin plates, preferring to see whether developments in the crude steel market would require reductions. The American Steel & Wire Company announced Feb. 23 that it would issue a new list on March 1, to which basis all shipments made Feb. 19 and later would be adjusted.

Pig Iron.

The pig-iron market has shown relatively little weakening tendency on account of the developments in the steel trade, although business, already very slow, was practically suspended. The tendency in pig iron would be to advance, in anticipation of the larger tonnage of business the reductions in steel prices tend to bring out ultimately, were it not for the fact that a reduction in ore prices is regarded by the trade, whether rightly or wrongly, as a distinct probability. The pig-iron market, as to the existing prices of raw materials, coke and ore, was thoroughly liquidated last October. While there was a rather sharp advance thereafter, about half the advance had been lost up to the time of the readjustment in steel prices, while there was an unduly large spread between pig iron and steel. Barring a possible reduction in ore, pig iron should advance rather than decline, but as it is some time may elapse before a trading basis is found satisfactory to both parties. Meanwhile the market in the central West can be quoted tentatively at $15 for foundry or basic and $15.50 for Bessemer, f.o.b. valley furnace; 90 cents higher delivered Pittsburgh.

Steel.

The billet, sheet bar and wire rod market has been slow in developing, chiefly on account of the system of basing prices on a Pittsburgh rate, plus freight to point of delivery not working out as satisfactorily in crude steel as it has in finished steel products. Practically all finished steel products, with the exception of rails, are customarily based on a Pittsburgh price plus rail freight to point of delivery. This was the rule with billets and sheet bars until about a year ago, when, on account of the shading of mills at a distance from Pittsburgh, a system was established of charging only half the freight advance from Pittsburgh, when the rate was from $1 to $3 a ton. This, with billets at $25, Pittsburgh, made the regular price $26.20, Philadelphia, the freight being $2.40, and $26.50, Chicago, the freight being $3. Even with these allowances it has been possible for months to shade the Philadelphia and Chicago prices, on attractive business, through the concessions of nearby steel works.

The High-Speed Tool-Steel Patent Decision.

The famous patent suit of the Bethlehem Steel Company against the Niles-Bement-Pond Company for infringement of two fundamental patents of F. W. Taylor and M. White (668,-369 and 668,270, both of Feb. 19, 1907,) has been decided in favor of the defendant, and the two Taylor-White patents in question have been found invalid by the Circuit Court of the United States for the District of New Jersey. Mr. Thomas W. Bakewell and Mr. Francis T. Chambers represented the complainant. Messrs. Duell, Warfield and Duell represented the defendant. The decision was written by District Judge Cross. We have prepared from the decision the following abstract:

"It is obvious that the question of the validity or non-validity of these patents is highly important, not only to the complainant and defendant, but to all workers in the art, since they apply to substantially all steels for cutting tools in the composition of which chromium and tungsten or molybdenum appear, and to all temperatures applied in treating such steel for such purposes in excess of 1725° Fahr. If the patents are sustained, any considerable progress in the art will manifestly be impossible during the period of monopoly thereby granted. This is not stated as a reason why they should not be sustained, if they properly may be, but rather to indicate the serious nature and importance of any conclusion that may be reached."

As to the character of the invention under dispute, reference is made to the first Taylor-White patent specification, where it is alleged that formerly (i. e., before 1900) the maximum temperature considered permissible for heating steel was from 1500° to 1550° Fahr. Taylor and White then continue: "Our invention is based on our discovery that while it is true that tools made of air-hardening steels all rapidly deteriorate at temperatures in excess of a bright cherry red (though it must be understood not all at the same temperature), it is also true that when air-hardening steels are made with certain constitu-

ent... ascertained proportions this deterioration only prevails during a limited range of temperature above the bright cherry red—that is to say, from about 1550° to 1700° Fahr. (corresponding to a light salmon color)—and on further discovery that above this range of temperatures, which we call the 'breaking-down point,' and from 1725° Fahr. up to a temperature at which the steel softens or crumbles when touched with a rod (approximately 1900° to 2000° Fahr.), the efficiency of tools of such special steels—that is to say, their cutting speed and also their uniformity in efficiency—is greatly increased and largely so in proportion to the degree of heat to which they are raised. This is sometimes the case that their cutting speed may be safely [illegible] from one and one half to two and a half times that of the tool heated, as heretofore, to temperatures below the breaking-down point."

The decision of the court emphasizes that there is no new composition of steel invented by Taylor and White. According to the testimony of Mr. White himself, there is no such thing as Taylor-White steel, but their patent simply claims a process for the *treatment* of a steel of certain limited compositions.

In the first patent their heat treatment is applied "by one set of claims to steels containing not less than ½ per cent chromium and 1 per cent tungsten, and by another set to steels containing 1 per cent of chromium and 4 per cent tungsten, and by all of the claims of the second patent to an air-hardening tool steel containing not less than 3 per cent chromium and not less than 6 per cent of tungsten. All of the claims, therefore, specify tool-steels containing certain percentages of chromium and tungsten, but they are clearly not limited to the percentages thus specified." * * * "This gives to the claim an extremely broad scope. The method of the patents is applied to almost every possible percentage of the chrome-tungsten composition of steel."

The decision of the court lays great stress on the alleged "breaking down point" between 1550° and 1725°, mentioned in the patent. "If such breaking-down point did not exist, or did not exist between the degrees of temperature named, the patentees made no discovery and no invention; or, again, if workers in the art were accustomed to temper their steel by the application of more or less heat, according to its composition, and in its treatment applied temperatures exceeding 1725°, the higher limit of the alleged breaking-down point, the patent must likewise fail.

"In the consideration of these questions, which to some extent overlap each other, it would seem that the prior art need not, and ought not, to be strictly limited to what was done in making metal-cutting tools of the precise character indicated in the patent. The questions involved, broadly considered, have to do with the tempering of steel, the use to which the steel might subsequently be put being relatively unimportant." * * *

"A reasonable application of this principle would seem to broaden the prior art, for if it were customary to temper steel in analogous arts by the application of very high temperatures, equaling and even exceeding those of the patents, and this without injury then the application of the same treatment, for a like purpose, to steels for metal-cutting tools would not necessarily involve invention."

Great stress is laid on the fact that there is no general rule as to the temperature to which steel is to be heated. Mr. John Fritz is quoted as saying that the temperature the steel will stand depends on its composition and that "if you know the composition of the steel you can generally tell pretty near what to do with it."

From Dr Hennig's testimony reference is made to the fact that "the Mushets in their circular and instructions for treating their steel specified a yellow heat for hardening, which temperature by all authorities given, was over 2000° Fahr."

Prof J. O. Arnold's testimony is then quoted, based upon "the experience of all high-speed steel makers," and upon certain specific experiments of his own, that there does *not* exist a "breaking-down point" between 1500° and 1750° Fahr., as claimed in the Taylor-White patent.

Reference is then made to "certain tests made at the complainant's works during the progress of this suit, in the presence of some of the counsel and experts of both parties." The object was "to repeat in open tests what had been done in a so-called secret trial and clearly show the existence of a breaking-down range for chrome-tungsten tools, and the inevitable response of chrome-tungsten steels to the treatment of the Taylor-White process, so called." The result of the open test was to show "that a heat of 1500°, regarded by the patent as the highest point of efficiency in the prior art, was, indeed, the lowest point of efficiency; that from 1550° to 1600° the same degree of efficiency, or rather of inefficiency, was substantially maintained; and that from and after a temperature of about 1600°, and not of 1725°, as called for by the patent, marked improvement was shown. In short, every material assertion of the patent bearing upon the point in question was disproved. In the presence of open tests, the private tests of either party must, to some extent give way, because they are relatively unsatisfactory; that is to say, ex-parte tests will almost invariably be found to support the theory of the party making them." * * *

"If then we accept these open tests at their face value, we would have this startling result, if the statement of the patent as to the prior art be accepted, that it was therein the custom, instead of heating a tool to the temperature which would impart to it its greatest efficiency, to heat it to a point which gave it its least efficiency, and this, notwithstanding the fact that from the earliest times all workers in steels, from the village blacksmith up, were accustomed by the use of a file and by other means to ascertain when a tool had attained its greatest efficiency.

"The testimony shows that it would have been impossible to make an efficient cutting tool out of the chrome-tungsten steel in vogue for some years prior to the patent in suit at a temperature below those within the patent in suit. Such steels not only required, but, in fact, were given, a much higher temperature than that given to the old carbon and cast steel, and a much higher heat treatment than 1725° named in the patent as the highest of the temperature defining the breaking-down point. The art developed continuously along this line as the carbon constituent was reduced and the toughening elements were introduced into the composition of steel.

"No satisfactory basis appears in the record for the assertion that the patents in suit led up to or were the means of producing or introducing the high-speed steels. On the contrary, such steels were developed normally along lines laid down and recognized prior to these patents. The process of their development has always been gradual, but at the same time consistent and in a single direction, and may well be characterized as one of degree, and the same may be said of their treatment.

"If the composition of steel were always uniform, the best heat treatment for that particular kind of steel, once ascertained, could safely be followed. But inasmuch as the compositions of steel are not uniform, but variable, and frequently unknown, it has always been more or less a matter of experiment to ascertain the degree of heat requisite for their proper treatment, and it is this experimental practice to ascertain what after all was merely a matter of degree that precludes all possibility of invention in the patents."

This ascertaining the proper temperature by experiment is pointed out in the testimony to have been Mr. John Fritz's method, while he was in the steel business up to 1894. "In view of what he says it must necessarily be inferred that if any of the steels of later composition had come into use in his day, he would have had no difficulty in ascertaining by experiment, as he had done with Mushet and other steels, the best method of treating them; it cannot be supposed for a moment that if he had found a steel which did not properly harden at 1550° that he would have been completely baffled and would have abandoned its use; on the contrary, his own testimony

shows he would have experimented with it, and heated it until it did respond, and properly, to the treatment, and in pursuing this course he would have done, as we shall see, no more than other practical men would have done, and uniformly did do in the prior art."

That the same experimental method has been followed by other steel men is concluded from the testimony of several experts. The court found that Taylor and White "substantially pursued" the same method. "In view of these findings it is impossible to see what of novelty and invention there was in what they did. Others were doing and had done the same thing. That they, by means of apparatus, more careful or different treatment, perhaps, and under highly favorable conditions, should have succeeded at one of the best-equipped shops in the country in producing, if they did, somewhat better tools than others produced, is neither invention nor evidence of invention."

Anticipation is found in "the Crescent public use" at the Crescent works of the Crucible Steel Company of America, for more than two years prior to the time when applications for the Taylor-White patents were filed. "The question, and this cannot be too carefully noted, is not whether the Crescent people made as good a tool as the complainant made under the patents, but rather whether, in making similar tools, they pursued substantially the same method."

"No small part of the complainant's testimony has been offered for the purpose of showing the utility of the patents," by offering as testimony articles from various publications. These are regarded as hearsay evidence.

The case is finally summed up as follows: "The prior art was radically different from what the patent would lead us to believe. There was no such thing known to the art as a breaking-down point. On the contrary, it is established that given a new steel, particularly if the composition were unknown, it was customary to experiment with and test and try it and thereby ascertain the best method of treating it; that in pursuing this course, the method of the patent was substantially followed and temperatures as high as any mentioned therein, or higher, were, not in isolated cases, but in ordinary practice, resorted to. Moreover, as a matter of fact, the patentees themselves in making their alleged discovery simply adopted the experimental rule which other workers in the art, both before and since, adopted and used, and if, in the race, the patentees have surpassed others, it has not been through novelty of procedure, but by means of special facilities, apparatus and methods not embraced in the patents.

"These patents in principle are not unlike the one considered and held invalid by the Circuit Court of Appeals for this circuit, in Brady Brass Company v. Ajax Metal Company, 160 Fed. 84, which turned upon the existence or non-existence in the prior art of a 'critical point.' The first of the headnotes to that case is as follows:

"'A mere difference in the proportions of the constituents of an alloy, however useful the result may be, does not entitle the originator to the monopoly of a patent, where such result was reached gradually by continued experimentation by the patentees and by others, all leading toward the same proportions, and the final product differs from those of the prior art only in degree.'

"It is with regret that, before closing, I feel constrained to give expression to the following criticism: The complainant's case, aside from the testimony of its expert witnesses, rests in no small degree upon that of a witness who, in the first instance when called by the defendant, showed a lack of memory and an unwillingness to testify as to matters concerning which it would seem as if he must have had more knowledge than he chose to reveal. However, when this same witness was called by the complainant a marked improvement in his attitude and memory was noticeable and he became a mainstay of its case. The record discloses, as it is undisputed, that not only this witness, but another important one, refused to testify for the complainant until after it had entered into an agreement with them by which, in consideration of their testimony, if the patents in suit were sustained they were to have licenses thereunder. The testimony of witnesses whose compensation is contingent upon the success of the party in whose behalf they testify, whose contingent compensation is furthermore an interest in the very subject matter of the litigation, who refuse to testify until after such contingent consideration is promised, who thereupon testify pursuant to the arrangement and subsequently demand and accept such contingent compensation, cannot but be impaired. Nor is this all, for the first of the witnesses referred to in the first instance demanded a pecuniary consideration for testifying, which he admits he regarded as prohibitive, while the second threatened to withdraw his testimony because of some delay in the delivery of the license, which he was to receive as compensation. It is not merely that such witnesses are interested, for that does not fully express their status: it is rather the character of their interest and the method of its acquirement; they dickered with the complainant for an interest in the *res* as the condition of their testifying. Their compensation, so far as they knew, was dependent upon the strength of their testimony and they had every inducement to make it effective. Furthermore, when testimony is first bartered for by a complainant in a court of equity under circumstances like the above, and the testimony given pursuant to the bargain is accepted and used, not only its equitable standing, but the strength of its case is likewise impaired, for the suggestion will not down that if some witnesses have testified under such an arrangement and for such a consideration, other wisnesses in the case may have done the same thing. If testimony of this character is acceptable upon the equity side of the court, it is not improbable that we shall soon have witnesses testifying in damage cases upon the law side, upon contingent fees of 5 per cent to 10 per cent of the amount of the verdict. Conduct of the character above outlined, if not contrary to public policy, is certainly near the border line."

CORRESPONDENCE

American Electrochemical Society Election.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—I have just sent to the secretary of the American Electrochemical Society the following letter:

Although I consider that my friends have done me a great honor in nominating me as one of the candidates for president of the American Electrochemical Society, I feel that I am not entitled to it as much as other candidates and therefore ask to kindly withdraw my name from the ballot.

If my friends judge that I can be useful to the society in some minor office, however humble it may be, I shall try to do what I can and work for the interest of our society; but let me start at the bottom of the ladder and not at the top.

Yonkers, N. Y. L. H. Baekeland.

Reduction of Iron Ore and Steel Refining in the Electric Furnace.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—In the September issue, 1908, of this journal (Vol. VI, page 353), Mr. Francis A. J. Fitzgerald criticizes several points in my paper, published in the August issue (Vol. VI, page 315). To these criticisms I wish to make the following reply:

In speaking of the "practical solution of a problem," I meant the whole system of technical contrivances by the joint action of which the object of the problem is carried out in practice in a convenient and commercially successful manner. This is the task of the engineer, and from this viewpoint I look at the reduction of ore in an electric furnace.

From the practical solution of the problem to its most general application and introduction there is still a long way;

[illegible] this end is beyond the power of the inventor and [illegible] the task of the promoter. I have built electric furnaces [illegible] for a sufficiently long period have been in regular [illegible] operation. *Forjable iron and steel have been produced directly from ore in a single operation.* Practice has shown that the process devised by me is not only convenient but quite economical. Hence, electrothermic reduction of iron ores is no longer a problem, but is an established fact, and I am ready to prove to Mr. Fitzgerald as well as to anybody who might be interested, the truth of my assertion. I do not talk about laboratory experiments, but will carry out the operation with a furnace of 1000 hp, the biggest ever used in electrothermic metallurgy.

It is true that there does not yet exist a second plant of my system where on a large scale iron ore is directly converted into iron and steel. But that does not matter, nor does it refute my statement that it was I who solved this problem in practice for the first time. Capitalists do not invest their money in any novelty at a first appeal. The greater the sum necessary for the erection of a plant on a proper scale, the longer will they hesitate. The inventor must procure the confidence of the public by his perseverance, leaving to the future the general introduction of his process.

The excellent results which I have obtained in my experiments confirm my conviction as to the perfection of my process; I shall persevere and delay does not frighten me. This is my answer to the first part of Mr. FitzGerald's letter. I hope I have been plain and have avoided any further false interpretations.

I now pass to the second part, in which Mr. Fitzgerald makes a calculation in order to show that according to the figures, which I give in my article, my process is not practical; first, on account of the 4 kw-hours of energy for every kilogram of steel produced; and secondly, on account of the cost of the energy itself, which is about half of what he believes it ought to be.

I cannot agree with my opponent on these points. The rate of 4 kw-hours is not exact, because naturally furnaces of large size would only be used for the reduction of ore by my process, and in these the consumption of energy is greatly diminished, as is shown by the figures in my former article. I repeat what I wrote about the consumption of energy:

"Further, on examining the figures of the different tables, one has to consider the size of the furnace which influences the consumption of energy; it is clear that a small furnace will consume more power per unit of output than a bigger one. For instance, in the refining of steel in the 200-hp furnaces at the Steel Works Stassano (average 1907) 1.26 kw-hours were consumed per kilogram of steel, while 2.3 kw-hours were required with the furnace of 100 hp."

It may be noticed that the experiments of direct extraction of iron from ore to which I refer, were carried out with a furnace of 200 hp. This was the same furnace which for purifying pig iron and scrap consumed in the average 1260 kw-hours for each ton of output (Table D), while the same work done in the furnace of 1000 hp (Table F) required only about 900-kw hours. It is obvious that when reducing ore in the 1000-hp furnace the consumption of energy will be less in the same proportion and will amount to less than 3-kw hours per kilogram of output. The ore used was rather low in quality, containing only 48 per cent of iron.

On the other hand, having never been in America, I cannot say with authority, whether, as Mr. FitzGerald pretends, his cost of the hp-year of energy on the new Continent may be right or wrong, although I have strong doubts about his assertion. All I can assert with certainty is that in Europe, and particularly in my own country, there are plenty of hydroelectric plants, partly existing, partly in course of erection, in which the cost of the hp-year amounts to less than 40 francs (about $8), all expenses, interest and amortization included, so that I would be the happiest of inventors if I should see my process introduced in only one-hundredth of these plants before I die.

Having thus shown that Mr. FitzGerald's figures are open to criticism it might not be necessary for me to reply to his final remarks if some facts did not compel me to say a few words about the "Lash process," described in Vol. V, pages 455 and 456 of Electrochemical and Metallurgical Industry.

From this article it really appears as though the inventor of this process believes to have come quite near the solution of such an important problem as the reduction of iron ore in an electrical furnace, using as reducing agent principally the ore itself, carbon and impurities of the pig iron granulated.

From this single description it seems evident, first, that in whatever shape this process is it is rather the purification of pig iron with the aid of the oxygen of the ore than a reduction of the ore. Secondly, if we consider the process, its practical economy seems very questionable on account of the small quantities of lathe scrap from pig iron, obtainable on the market at a low price. To take pig iron from the furnace and granulate it would be prohibitive on account of the expense.

Further, if a mixture is made as proposed in this paper, consisting of 54 per cent of iron ore, 27 per cent of granulated pig iron, 4 per cent of sawdust, 4 per cent of limestone, 3 per cent of tar, and 8 per cent of coke, this mixture, molten in an electric furnace, will prove a failure, as I am ready to show at any time, except if iron ore of extreme purity and granulated charcoal pig iron are used.

I further think it necessary to point out that in an article published February, 1902, in the *Revista d'Artiglieria & Genio* (Vol. 1), I described the entire series of experiments made by me during the preceding years and by which I established the most suitable form of the furnaces which were patented 1900 and 1901 and have been in industrial operation ever since, and then wrote as follows:

"After these favorable results I abandoned, without hesitation, the cupola shape, which was the original shape of my furnaces, and adopted the shallow kind. Changed in this manner the furnace, as may be easily understood, is not only suitable for treating mixtures of ore, but is likewise adapted for the refinement of pig iron in accordance with the open-hearth process, while at the same time it serves as a simple melting furnace.

"As air cannot penetrate into the furnace, the purification of the pig iron requires the introduction of oxygen in form of ore and in sufficient quantity to burn all the impurities. This is merely the common way, known in the metallurgy of iron by its English name of 'ore process.' The ore gets rid of the oxygen and the latter oxidizes the impurities of the pig iron.

"Numerous tests made with the furnace, transformed in this kind, gave evidence that anything that I had figured out a priori to be obtainable was obtained in practice. On account of the aforesaid modification I really have been able to produce, at will, malleable iron, steel, alloys of iron with other metals as manganese, chromium, nickel, etc., either by direct extraction from the ore, or by refining pig iron according to the 'ore process,' and also ingots of iron and steel by melting large lumps of scrap or fine scrap of these materials."

Hence, the refining of pig iron by aid of the iron-ore process, which after all forms the base of the Lash process, is not at all new, having been studied and experimented by me before 1900 and ever since employed industrially. It is used with my furnace at the Royal Artillery Works at Turin since spring 1903; it has been in use without interruption with the furnaces of the Electric Steel Works "Forni Elettrici Stassano" at Turin, which I fully decribed in my article of August last, and also with the furnace at the Bonner Fräserfabrik at Bonn, Germany (now Rheinische Electro Stahl Werke), also mentioned in my former article.

Turin, Italy. Ernesto Stassano.

Apparatus for Electrolytic Refining of Precious Metals.

By H. Lacroix.

In precious-metal refineries the chief endeavor has been in the past to improve the chemical and electrochemical features of the refining process, to select the best conditions of density, composition of electrolyte, temperature, acidity, etc. The mechanical side of the problem has been rather seriously neglected, so that highly perfected processes are being carried out in rather rudimentary apparatus.

The tanks employed in gold and silver refineries are almost always simple rectangular boxes, generally of wood.

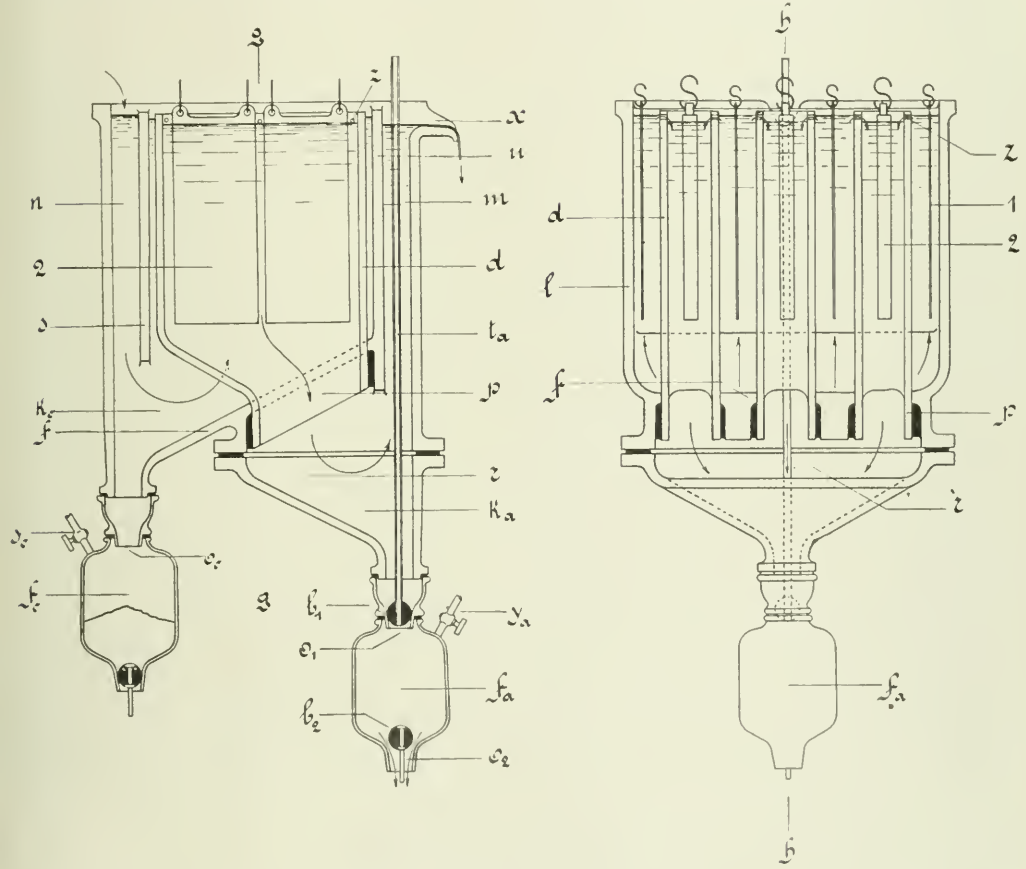


FIG. 1.—SECTIONS OF ELECTROLYTIC REFINING APPARATUS.

In the Moebius process of silver refining the electrolysis is carried out in tanks of this kind and the anodes are contained in canvas bags. The anode slime accumulates within these bags. When the anodes are consumed, the operation is interrupted and the bags are emptied. The cleaning of these bags is a long and delicate operation, which may easily involve serious losses.

The Wohlwill process of gold refining, which has been thoroughly studied from the electrochemical standpoint, is also carried out in simple tanks without diaphragm between the electrodes. On this account it is necessary to use as starting anode material an alloy containing very little silver and to employ only a slight circulation of the electrolyte, as otherwise silver chloride might be mechanically carried over onto the cathodes.

Circulation of the electrolyte is almost always employed, but the methods are generally crude, circulation being obtained by stirring or other simple means. In some cases the electrolyte is introduced into the tank at one end and flows off at the other end, but attention is hardly paid to the exact path of the electrolyte through the tank.

Theory as well as practical experience prove, however, that it is advantageous to separate the anodic and cathodic portions of the electrolyte and to maintain the density of the electrolyte constant all over the surface of the electrodes by continually bringing fresh electrolyte to the electrode surface.

These considerations have led the author to design the apparatus shown in two sections on Fig. 1. In practice it has given so far excellent results.

The anodic compartment comprises the space within the diaphragm cells *d*, the reservoir *r*, and the exit channel *m* which leads to the overflow *x*.

The cathodic compartment comprises the space outside of the diaphragms *d* and the reservoir k_e with the walls *u s* and the inclined bottom *f*. There are holes in this inclined bottom, and through these holes pass the lower parts *p* of the diaphragm cells which are thus in communication with the lower reservoir *r*.

1 are the cathodes, 2 the anodes. The anodes 2 consist, of course, of the alloy to be refined and are suspended within the

diaphragm cell. The electrolyte is in continuous circulation through the electrolyzing tank; it enters through the channel *n*, passes to the bottom of the cathode compartment, rises upward along the cathodes, passes over into the diaphragm cells through the holes *z* near the top, runs downward along the anodes into the space *r*, rises again through the channel *m* and leaves the electrolyzer through the overflow *x*.

During electrolysis the insoluble constituents of the anodes (the anode slime) fall down through *p*. The heaviest particles slide on the inclined bottom of k_a and accumulate in f_a. The lightest particles—those which tend to fall downward with less speed than the speed with which the electrolyte rises upward in the channel *m*—are taken along by the electrolyte to the outside of the cell and are there recovered by filtration.

Any particles of cathodic deposit which do not adhere to the cathode surface fall onto the inclined bottom *f* and accumulate in f_c.

In this way the different constituents of the anode are automatically and continuously separated into the following parts:

(1) Adhering cathode deposit, i. e., pure refined metal.

(2) Non-adhering cathode deposit which accumulates in f_c.

(3) Heavy anode slimes, accumulating in f_a.

(4) Light anode slime, recovered on a filter outside of the tanks.

The flasks f_a and f_c are emptied as follows:

The globe valve *b*, which is normally raised above its seat or even completely removed from the apparatus, is first pushed down by means of the long hollow tube t_a so as to close the aperture o_1. By any suitable means, preferably by a proper receiving flask (not shown in the illustration) the globe valve b_2 is then raised and flask f_a is emptied while air enters through the hollow tube t_a.

When f_a is emptied, the globe valve b_2 is replaced so as to close the bottom hole and by means of Y_a the flask f_a is brought into communication with an outside reservoir containing electrolyte, its level being the same as in the electrolyzing tanks. The flask f_a is thus filled with electrolyte while the air escapes through the long hollow tube t_a. The cock Y_a is then closed again and communication between *r* and f_a is re-established by raising the valve b_1. This requires no effort, since the pressure is the same on both sides, nor does it cause any agitation nor any variation of the level of the electrolyte in the tanks.

It will be seen that the apparatus permits absolutely continuous operation, since the emptying of the flasks f_a and f_c and the renewal of anodes and cathodes does not require interruption of operation and may be done at any moment. For instance, it is unnecessary to wait with the removal of the anode slime until the anodes are completely consumed (which is, of course, unavoidable when the anodes are enclosed in canvas bags. This is quite an important point, since we have to do with slimes rich in gold and the interest item enters into the cost sheet.

This method of disposing of the slimes results in an operation with a minimum of loss. This is not unimportant, as an electrolyte of chloride of gold is employed, for instance, containing 30 grams per liter. The hands of the attendants do not come in contact with the electrolyte nor with any part of the apparatus which is wetted by the electrolyte.

The forced circulation of the electrolyte along the electrodes permits to maintain an absolute uniform density all over the surface and consequently results in a perfectly uniform consumption of the anode and a perfectly uniform deposit on the cathode.

In ordinary tanks without circulation or with circulation by means of stirring, the anodes are consumed in such a way as to assume the form shown in Fig. 2, the bottom part being much more quickly consumed than the upper parts. The anodes, therefore, gradually assume a wedge shape. (The dotted lines represent the original shape, the drawn-out lines the shape later on.) On the other hand, with the apparatus as described above, the consumption of the anodes is as shown in Fig. 3, the anode being corroded equally all over the surface so that at all times the two surfaces of the anode plate remain truly parallel. This enables one to use the full current to the last moment.

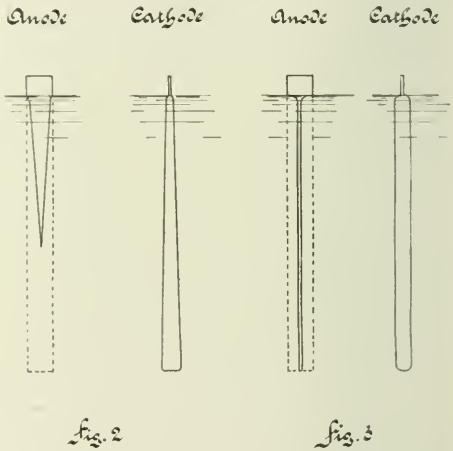
The rest, which is not consumed and which is returned to the foundry, is less than 8 per cent of the original anode weight.

This apparatus may be successfully employed for refining gold by the Wohlwill process, or silver by the Moebius process, or copper-silver-gold alloys by the Dietzel process.

As to **gold refining**, the Wohlwill process is well known and has been repeatedly discussed at length in this journal.

By the use of the apparatus described above, it is possible to treat by the Wohlwill process gold alloys relatively rich in silver (containing up to 15 per cent silver), yielding gold of 100 per cent purity at the cathode.

The particles of silver chloride which detach themselves from the anodes or are scraped off, drop into the lower reservoir *r*



FIGS. 2 AND 3.—CONSUMPTION OF ANODES AND DEPOSITION ON CATHODES WITH UNIFORM AND NON-UNIFORM DENSITY OF ELECTROLYTE.

and accumulate in the flask f_a, from which they may be removed at will.

The electrolyte when enriched in gold in the diaphragm cells at the anode surfaces, leaves the tank through the overflow *x* and after filtration it is fed back to the tank into the cathode compartments and gives off gold to the cathodes. However this circulation may be carried out, it is impossible for silver chloride particles to be deposited on the cathode together with the gold. It is further possible, even with a comparatively high proportion of silver in the anodes, to use a current density above 10 amp per square decimeter, with sufficiently strong circulation.

In **refining silver** by the Moebius process the silver is deposited in form of crystals on the cathodes. When scraped off, the silver drops on the inclined bottom *f* and collects in the flask f_c.

The insoluble anode slime, consisting principally of gold, falls into the reservoir *r* and accumulates in the flask f_a. The electrolyte is returned after filtration to the cathodic compartment.

In the Dietzel process for **refining copper-silver-gold alloys** the cathodes are made of copper and the cathodic deposit consists of copper. Silver, copper and some impurities pass from the anodes into the electrolyte, while gold and other insoluble constituents drop into the flask f_a. The electrolyte running off from the anode compartment of the tanks contains silver nitrate and copper nitrate. Outside of the tank the silver is almost completely precipiated on copper. The electrolyte

is then passed into the cathode compartment of the tank where the copper is alone deposited.

The apparatus described above is particularly suitable for this process and permits the treatment of alloys of such variable composition as between 50 and 99 per cent silver and between 0 and 28 per cent gold, yielding silver of 99.9 per cent purity, gold of 100 per cent and copper of 99.8 per cent.

Serious difficulties had to be met in the construction and installation of this apparatus, but they have been successfully overcome and various electrolyzers of this type, which are patented in all principal countries, have been in regular operation for about two years.

Genève, Switzerland. Usine de Dégrossissage d'Or.

Bakelite.

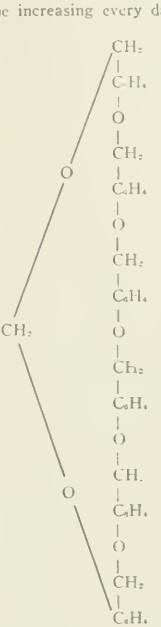
At the meeting of the New York section of the American Chemical Society, on Feb. 5, Dr. L. H. Baekeland presented a paper which was the first authoritative announcement on the manufacture and properties of "bakelite." This is Dr. Baekeland's latest invention, which he is known to have been developing quietly for a number of years. While in the present paper the chemical side of the subject was principally dealt with, other sides of the subject will be discussed in further papers, one of which is to be presented before the American Electrochemical Society.

The paper was most attentively listened to, and was received with considerable enthusiasm by a large audience. Dr. Baekeland has already proven in the past a most successful photochemist by his invention of "velox" paper for photographical purposes. He has also shown himself to be an excellent electrochemist and chemical engineer, as in installing the Townsend diaphragm process for operation on a large scale at the works of the Development and Funding Company, in Niagara Falls, he was pre-eminently active. Now his latest invention, "bakelite," appears to be one of very wide scope and usefulness. The following abstract gives all essential facts. The paper in full, which is very long, will be printed in the April issue of the *Journal of Industrial Chemistry* of the American Chemical Society.

Phenols and formaldehyde under special conditions may give the most different condensation products; some of these are soluble in water, like phenol-alcohols, others are crystalline, while others are resinous masses. Among the latter are some resins that are soluble in alcohol and fusible, and which are more generally known under the name of shellac substitutes. Bakelite is very different in as far as it is infusible and no known solvents can dissolve it. Furthermore, it withstands alkalies, chlorine and in general almost all chemicals. Boiling concentrated sulphuric acid or nitric acid destroys it, but it stands very well dilute boiling sulphuric acid.

Bakelite is an excellent insulator. It resists temperatures as high as 300° C. without melting or softening. Heated at the temperature of melting glass it chars, but does not enter into fusion. It seems to combine some of the properties of amber, celluloid and hard rubber. Its weak point is that it is not as elastic as hard rubber or celluloid, and, therefore, cannot be used whenever great flexibility is required. In other ways it is much superior to both these products, because it stands heat, solvents and chemicals much better and is considerably less expensive.

Dr. Baekeland has tried to determine the molecular weight of bakelite. This is no easy matter if we take in consideration that we have to deal here with a substance which, on account of its physical and chemical inertness, does not lend itself to any of the usual methods for molecular weight determinations. He succeeded, however, in preparing the substance by indirect synthesis by starting from alcohol-phenols and comes to the conclusion that it is a polymer of oxybenzyl-alcohol-methyl-englycol-anhydride or its homologs. The formula is $n\,(C_{45}H_{38}O_7)$, while the structural formula can be assumed as shown below.



The useful applications of this interesting substance seem to be increasing every day. Dr. Backeland mentioned that applications are being tried in more than 40 different industries. Besides its minor uses in fancy articles, like ornaments, pipestems, knife handles, billiard balls, etc., it seems to be destined to bring about great changes in the wood-working industry.

In one of the modifications of the bakelite process, operations are arranged in such a way so as to have the synthesis occur inside the fibers of wood so that soft and inexpensive wood can be changed into wood as hard as ebony, that besides possessing a greater strength, becomes entirely rot proof. In the same way, wood can be coated with a thin layer of bakelite, which gives it an unusually pleasant finish, superior to the most expensive Japanese lacquer and which can stand boiling in hot water with impunity, without the slightest deterioration of the pretty finish. This was shown by direct experiment where a bakelite-finished brush handle was kept in boiling water for about an hour. In the same way coils or windings of dynamos or motors can be impregnated with bakelite, and this leads one to expect that this use may reduce considerably the danger of burning-out of motors and dynamos run under overload.

Several molded electrical insulators were shown by Dr. Baekeland, containing bakelite in admixture with other substances, like asbestos or mica, and which, on account of their great strength, accurate molding and resistance to heat, seem a great improvement on porcelain insulators or such ones in which vegetable or fossile resins are used.

Bakelite in conjunction with sand or similar inert materials makes an excellent coating for metallic machinery, such as is used in chemical engineering; but the best example of the unusual variety of applications of bakelite is the fact that at the meeting were shown a grindstone made of bakelite, and at the same time a self-lubricating bearing which had been tested dry for nine hours at 1800 r.p.m., without causing any heating or any injury to the quickly revolving shaft. That such bearings can be molded rapidly and very accurately to any size and shape to within a thousandth of an inch, may open some new possibilities in this branch of engineering.

Steam packing that can withstand chemical solutions and high-pressure steam has also been made with bakelite. Its advantages in that direction are very obvious, as a piece of molded bakelite was shown which had been heated in water for eight hour under pressure in an autoclave at 200° C., together with some pieces of glass. The latter had become very much disintegrated and showed the effect of water at high temperature, while bakelite seemed entirely unaffected.

The bakelite process can be summarized as follows:

Phenol and formaldehyde are heated together in presence of a small amount of a base which acts as a catalytic agent. This gives the "initial condensation product," which is called *A*, the chemical nature of which is variable according to the degree of condensation. It may be obtained either as a liquid or as a paste, or even in solid form. In the latter case it is brittle like resin at ordinary temperatures, but it melts if heated.

If heated further it may change into *B* or *C*. All varieties of *A* are soluble in alcohol or acetone or similar solvents, they are

also soluble in alkalies, but their main characteristic is that if heated under proper conditions they will ultimately transform into *B* or *C*.

B is called the "intermediate condensation product." Chemically *A* may be considered to be the anhydride of which *C* is the polymer. At ordinary temperature *B* is also a brittle substance which can easily be pulverized. If slightly heated it softens without melting and becomes elastic, but on cooling it again returns to its brittle condition. No amount of heating will melt it, and if heated long enough it will change into *C* without losing its shape. This fact, as will be seen further on, is of extreme importance for simplifying the molding process of bakelite. *B* shows further difference from *A* because it is insoluble in all known solvents, but it swells in phenol and in acetone, without, however, entering into complete solution.

C is the final product, the direct polymer of *B*. It is called also "the final condensation product." It is infusible, does not even soften when heated, does not swell in phenol or in acetone, and is generally inert against chemical and physical agents.

The fact that *C* once produced cannot be molded, nor pressed, nor given any shape except by cutting, sawing, filing or turning, makes it necessary that all the preliminary work in the bakelite process has to be done with the substance in condition *A* or *B*.

We quote the following from what the speaker said on the subject of molding:

"For all plastics, like rubber, celluloid, resins, etc., the molding problem is a very important one. Several substances which otherwise might be very valuable are useless now, because they cannot be molded economically. The great success of celluloid has mainly been due to the fact that it can easily be molded. Nitrated cellulose alone is far superior in chemical qualities to celluloid, but until Hyatt's discovery it could only be given a shape by an evaporation process and its applications were very limited. The addition of camphor and a small amount of solvent to cellulose nitrate was a masterstroke because it allowed quick and economic molding.

"In the same way white sand or silica would be an ideal substance for a good many purposes could it be easily compressed or molded into shape and a homogeneous mass. But it *cannot;* and, therefore, remains worthless. And that is the main difference between a *plastic* and a *non-plastic* substance.

"It so happens that bakelite in *C* condition does not mold; it does not weld together under pressure even if heated; only with much effort is it possible to mold some kind of an object out of it, but some way or another the particles do not stick well together; in other terms, it is not a true plastic. Therefore, the molding problem has to be solved in the anterior stages of the process.

"I have already shown you how I am able to mold and harden quickly by pouring liquid *A* into a mold and heating it in a bakelizer But even that method is much too slow for most purposes Furthermore, molds cost money; any rubber or celluloid manufacturer will tell you that the item of molds represents a big portion of the cost of his plant If an order for 10,000 pieces has to be delivered and it takes an hour for molding, it will require between three and four years to fill this order with one mold; and if the mold costs $100, it will require $5,000 for molds alone if the order has to be finished within 20 days For that very reason I have devised my molding methods so as to use the molds only during the very minimum of time.

"As stated before, the use of bases permits me to make a variety of *A* that is solid, although still fusible. The latter is as brittle as ordinary resin and can be pulverized and mixed with suitable filling materials. A mixture of this kind is introduced in a mold and put in the hydraulic press, the mold being heated to temperatures preferably about 160° to 200° C. The *A* melts and mixes with the filler, impregnating everything, at the same time it is rapidly transformed into *B*. But I have told you that *B* does not melt, so the molded object can be expelled out of the mold after a very short time and the mold can again be refilled. All the molded articles are put in the *bakelizer* and this, of course, without the use of any molds; in this way they are finally transformed into 'C-bakelite' of maximum strength and hardness and resisting power.

"The process can still be further simplified. Instead of using pulverized *A*, we can use powdered *B* and mold it in the hot press, where it welds and shapes itself. After a very short time the *B* begins to transform into *C* and can now be expelled from the mold. If the transformation into *C* is not complete, a short after-treatment in the bakelizer will finish everything. I have succeeded thus in reducing the molding to less than two minutes for small objects."

In the above quotation the reference was made to a "Bakelizer" and this requires a word of explanation. Dr. Baekeland has found that the best temperatures for the rapid and thorough transformation into *C* are situated between 160° and 200° C., but he has also discovered that at temperatures above 100° C. *A* undergoes a beginning dissociation which sets free CH_2O in gaseous form and this causes the formation of bubbles in the mass and renders it porous and technically worthless. By studying this tension of dissociation he was able to find a way of counteracting it by opposing external pressure until condition *C* is reached, when no such further dissociation can occur. That is the reason why he heats under artificially raised pressure, for instance, in closed molds or in a heated hydraulic press. In other instances he introduces the object in a bakelizer.

This is the name of an apparatus in which there is an interior chamber in which air can be pumped to a pressure from 50 lb. to 100 lb. per square inch. After the objects which have to be bakelized are introduced into it, then by means of a steam jacket or any other suitable heating device, they are heated to temperatures of 160° C. or higher.

In the beginning of his paper Dr. Baekeland gave a detailed description of all the scientific and patent literature which has a direct bearing on this subject, so as to differentiate clearly his own processes, which are protected by many patents here and abroad. In the United States alone he has 14 patents pending, which have not yet been published.

Water Decomposition by Direct Current and Alternating Current, and Welding with the Oxy-Hydrogen Flame.

By M. U. Schoop.

Water is decomposed by direct current in the proportion of one part by volume of oxygen to two of hydrogen. This proportion is not directly suitable for welding metals, since the oxy-hydrogen welding flame should always have an excess of hydrogen.

When experimenting with alternating-current electrolysis, I found that electrolysis of acidulated water yields directly a mixture of oxygen and hydrogen gases suitable for welding. By varying voltage and frequency I always found it possible within certain limits to produce a mixture of gases which differed more or less from the theoretical ratio of 1 to 2. Unfortunately, these experiments had to be discontinued. The results of the incomplete investigation are buried in the laboratory records of a large storage battery factory.

These notes may perhaps give an incentive to others to again take up this problem. It may become possible to work out a practical method by which anybody who has electricity supply in his shop can make himself at a low cost the oxy-hydrogen gas required for welding, without using expensive electrolyzers like those of Garuti, Schmidt, Schoop, and others, in which the two gases are obtained separately.

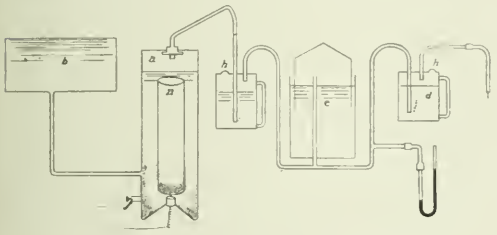
The objection may be raised that there is considerable danger in handling any, however small, volume of mixed hydrogen and oxygen gases. But it should be understood that the usual weld-

ing equipment and the ordinary water electrolyzers are free from danger. Only the electrolyzing cells operate in a safe and reliable manner, and are attended by careful and skilled laborers. Explosions of rather destructive nature have occurred, for instance, in the storage battery factories of G. Hagen, in Kalk, and of the A. F. A. G., in Hagen, Germany, in the hydrogen works in Lucerne, Switzerland, in Griesheim-Elektron, and at other places.

For many purposes it would be sufficient to use an oxy-hydrogen mixture in equivalent proportions, to which is added some atmospheric air (the nitrogen being simply inert). For instance, this would do for operating internal combustion engines, instead of using illuminating gas or gasolene. Also for welding metals of a low melting point, like lead; for illuminating and for soldering work of all kinds.

If the oxy-hydrogen gas is developed under a pressure of a water column of 1½ to 2 meters, it is easy to introduce the air by suction by means of an injector nozzle. In order to exactly regulate the proportion of the mixture of the oxy-hydrogen gas with the atmospheric air, the oxy-hydrogen gas could also be sucked from the electrolyzer by means of a suitable pump.

By far most oxy-hydrogen burners have the inherent disadvantage that the mixture of the two gases occurs only just before their exit, and that a perfectly intimate mixture cannot be obtained even if a mixing chamber is provided. It was evidently for the sake of safety that designers endeavored to



APPARATUS FOR MAKING OXY-HYDROGEN GAS.

shorten as much as possible the path of the explosible gas mixture in the burner, so that they did not provide a path along which the two gases would have an opportunity to mix perfectly.

But that a rather intimate mixture is very important for the temperature and quality of the flame is at once evident. In this respect an electrolyzer yielding directly a mixture of oxygen and hydrogen gases would have certain advantages.

Theory and practice show that a striking back of the flame can occur only if the speed of the gas mixture when leaving the nozzle is less than that with which the ignition is propagated. From a practical point of view this means that the opening of the burner must be adapted to the size of the flame and to the pressure of the gas. Even when using the most dangerous mixture of gases there is no possibility of striking back if the gas is emitted under sufficient pressure.

The apparatus used in my experiments was as follows: A cylindrical vessel of sheet lead, 2 millimeters thick, contained two lead electrodes of large surface (for instance, not-formed accumulator plates of the Plante type). The construction becomes one of great simplicity if, as shown in the adjoining diagram, the containing vessel *a* itself is made one electrode, say the cathode, and a lead pipe *a* closed at the bottom and open at the top, is used as positive electrodes.

b is a reservoir containing water to replace the water decomposed in *a a* by the electric current.

c is a gasometer and *n* a wash bottle which holds back any acid particles which may be carried along with the gases. It is advisable to use a number of gasometers in series, a wash bottle being always inserted in the connecting line between two gasometers. This gives a certain buffer effect. For reasons given later on, all the apparatus is made of lead. Sulphuric acid of 1.20 specific gravity is used as electrolyte.

In 1901 I made experiments with soft-lead cylinders of 60 cm length and 35 cm diameter, in order to study the effect of an explosion of an oxy-hydrogen gas mixture in such containers. The result was quite surprising. Although these cylinders were made of soft lead sheets, only 1 millimeter thick, an explosion of the hydrogen and oxygen mixture in the theoretical proportion of 2 to 1 did not result in a destruction of the cylinder. The cylinder form was simply distorted into a shape similar to that of the globe. Even a second explosion when brought about in the same container, did not result in any destructive tearing apart of the container; the result was simply a true globe, while cracks formed along the soldering seams.

It is to be regretted that I did not make analogous experiments with cylinders of other material, like hard lead or iron sheets. I have no doubt the result would have been quite different.

The oxy-hydrogen gas was used under atmospheric pressure. It is doubtful whether the result would have been essentially different if a pressure of 60 to 70 millimeters water column had been used, such as is sufficient in most cases for welding. It would seem that such soft lead containers could be usefully employed in any case where explosible gas mixtures are handled.

A simple safety device is to solder to a container of explosive gases a little lead sheet (1/5 mm) which is first torn off in case of an explosion. Such little safety sheets are marked *h h* in the diagram.

Another safety device, about which I cannot say anything, however, from practical experience, would be to surround the container with a strong wire net. It is also known that in very finely subdivided spaces, such as are obtained by a filling with iron files or glass wool, a destructive explosion cannot occur. By means of cylinders filled with glass wool it is even possible to arrest the propagation of an explosion completely.

Finally, after everything imaginable has been done to eliminate any danger of explosion, I would still advise to take out an insurance policy.

If alternating current is not available, but only direct current, it becomes necessary to remove part of the oxygen in some way, or to introduce continually hydrogen gas into the gasometer. A possible method is to pass the oxy-hydrogen gas mixture through a slightly alkaline pyrogallol solution, whereby part of the oxygen is absorbed by the solution. Physical methods of separation, for instance, by centrifugal force with very high speeds of rotation, might also be tried.

To estimate quickly the composition of a gas mixture, the simplest way is to make soap bubbles. With some experience the more or less noisy detonation indicates directly whether the composition is right for welding or whether one has too much oxygen or hydrogen. The pipe (for making the soap bubbles) is a sensitive and easy analytical apparatus. The pitch of the tone depends not only on the length of the vibrating gas column, but on the elasticity of the medium. For instance, heated air or illuminating gas or hydrogen gas give a higher tone than cold air under otherwise identical conditions. A suitable pipe is therefore an exceedingly simple apparatus for making in a few seconds a reliable analysis. In this way it is, for instance, possible to detect 1 per cent of oxygen in pure hydrogen.[1]

There can be no doubt that a simple and cheap method of making oxygen and hydrogen gases would do much to increase the popularity of the oxy-hydrogen flame for welding all kinds of metals. The transport of compressed gases in steel bottles is very troublesome, and the handling of the bottles and the valves is not without danger, in spite of all statements to the contrary.

For large consumers a liquid air plant on the Linde or Claude

[1] See *Sitzungsberichte* der El. Ges. in Köln, Dec. 19, 1901, paper of the author on industrial electrolysis of water. See also Victor Engelhardt's Electrolysis of Water, and M. U. Schoop, Die industrielle Elektrolyse des Wassers.

system for making oxygen gas is profitable. For small consumers the problem of making oxygen gas cheaply has not yet been solved.

The chemical methods are hardly suitable for industrial purposes. The products[2] hydrolithe and oxylithe, invented by Imbert in Paris, are interesting, since they are used in the same way as calcium carbide, yielding hydrogen and oxygen gases in contact with water. One kilogram hydrolithe yields 1000 liters hydrogen and 1 kilogram oxylithe 700 liters oxygen. But it is very questionable whether these substances can be made cheaply enough to enter into competition at such places where compressed hydrogen and oxygen gases are available.

With the present very low price of aluminium, namely, francs 1.30 per kilogram for aluminium ingots (12 cents per pound) and franc 0.50 to 0.60 per kilogram of aluminium scrap (4 to 5 cents per pound) it is possible to use aluminium on a large scale for making hydrogen gas. It is known that in the Japanese War the Russians made the hydrogen for their balloons from aluminium and caustic soda solution.

Under certain conditions aluminium will directly decompose pure water; namely, when its surface is freed from the ever present invisible oxide film. If an aluminium sheet is etched with mercury chloride solution, the reaction of aluminium with water can be shown very clearly. The equation is

$$2\,Al + 6\,H_2O = 2\,Al(OH)_3 + 3H_2.$$

27 kilograms of aluminium yield 3 kilograms of hydrogen, or 1 kilogram of aluminium yields 1300 liters of hydrogen.

The residue is pure aluminium hydroxide of pure white color; by selling this the cost of making the hydrogen gets very reasonable.

Care must be taken that the heat evolved during the reaction does not raise the temperature to the boiling point, since in this case the efficiency of hydrogen production drops far below the theoretical value.

Presence of small quantities of foreign metals, like copper, seems to facilitate the reaction. If turnings or other scrap are used a preliminary cleaning is, of course, necessary to remove any fat.

Garenne-Colombes, near Paris, France.

Monel Metal.

By David H. Browne.

During the last three years the International Nickel Co. has been investigating the physical and chemical properties of a new alloy of nickel and copper which is now coming into commercial use under the name of Monel metal. This alloy has at the present time been put to so many uses and possesses such remarkable properties that a brief description of these may be of general interest.

Monel metal consists primarily of nickel and copper in the proportion of three parts of nickel to one part of copper, this being the natural proportion in which these metals exist in the largest deposits of nickel ore in the Sudbury district. Throughout its entire manufacture this alloy acts as a single metal, and while the proof is still incomplete, evidence seems to show that in these proportions nickel and copper have a remarkable affinity for each other.

Like steel, this alloy absorbs carbon, and, like steel, its physical properties are profoundly influenced not only by the percentages of carbon, silicon, etc., but by the heat treatment it receives.

A standard analysis of monel metal is as follows:

Nickel	68	to 72	per cent.
Iron	0.5	to 1.5	" "
Sulphur	0.014	"	"
Carbon	0.073	to 0.15	" "
Copper	to balance.		

[2] In this country chemical compounds, serving the same purpose, are made by the Roessler & Hasslacher Chemical Co. and known under the trade names hydrone and oxone.—Ed.

This alloy is silver-white and takes a brilliant finish, which it retains indefinitely. On prolonged exposure the surface assumes a grayish cast, which may be easily removed with a polishing cloth.

In the rolled sheets, the surface assumes on heating a coating of oxide which has great resistance to acids. Samples of the rolled metal show no loss in 56 days test in pumping 40° sulphuric acid.

An especial pickle has to be used to remove the oxide coat for articles destined to be polished, but for purposes where resistance to acid is required, the oxide coating is allowed to remain.

Monel metal melts at 1350° C. It can be rolled perfectly from 900° to 1200° C., and its annealing temperature is above 875° C. It can be finished hard or soft, like sheet copper. Its specific gravity, as cast, is from 8.86 to 8.87, and when rolled from 8.94 to 8.95.

The cast Monel metal is at present made in two grades, with the following qualities:

	Grade C.	Grade D.
Tensile strength	70,000	85,000
Elastic limit	27,000	40,000
Elongation in 2 inches	30%	25%
Reduction of area	35%	25%

These compare very favorably with the government specifications for carbon-steel castings, viz.:

	Hard.	Medium.	Soft.
Tensile strength	85,000	70,000	60,000
Elastic limit	38,250	31,000	27,000
Elongation	15%	18%	22%
Contraction	20%	25%	30%

In the rolled and annealed condition Monel metal is stronger than nickel steel, as the following tests will show:

	Monel metal 1-in. rods. As rolled.	Average tests. Rolled, annealed and cold drawn.
Tensile strength	100,000	110,000
Elastic limit	50,000	80,000
Elongation 2 inches	30%	25%
Reduction of area	50%	50%

For comparison the specifications of steel forgings are given below:

	Carbon steel. Annealed.	Carbon steel. Oil tempered.	Nickel steel. Annealed.	Nickel steel. Oil tempered.
Tensile strength	80,000	90,000	80,000	95,000
Elastic limit	40,000	55,000	50,000	65,000
Elongation 2 inches	22%	20%	25%	21%
Reduction of area	35%	45%	45%	50%

Some tests of ½-in. rolled plates furnish an interesting comparison with soft steel and copper.

	Monel metal.	Soft steel.	Copper.
Tensile strength	90,000	60,000	34,000
Elastic limit	45,000	30,000	18,000
Elongation 2 inches	30%	35%	52%
Reduction of area	60%	35%	57%

We have here a metal possessing about 25 per cent greater tensile strength and 50 per cent greater elastic limit than the best rolled steel, with the additional quality of incorrodibility. The mechanical possibilities open to such an alloy are endless.

During the last year some 300,000 sq. ft. of Monel metal sheets were used to roof the Pennsylvania terminal station in New York City. The manufacturers, who have tested this material for roofing, state that they find it as easily worked as copper.

The sheets are silvery white, exceedingly flexible and malleable, and are handled in exactly the same way as sheet copper.

The rolled metal has been drawn into wire of all sizes down to 0.004 in. This latter is as soft and pliable as a silk thread. In the form of wire exhaustive tests have been made of the metal for window screens, bed springs, filter cloths and other purposes where its incorrodibility makes it especially effective.

In small articles, such as tacks, bolts, screws, angle braces and such stamped work as door and window trimmings, hinges, gas and electric fittings, and other small articles too numerous to mention, it is rapidly finding its way into the market.

The metal works on the lathe as well as soft steel without chattering or jumping. It has been spun and pressed into hollow-ware, kitchen utensils, watch cases, finger bowls, with the same ease as copper or silver. The superiority of such metal over nickel-plated brass, from which the coating is easily removed by polishing, is self-evident.

One of the most satisfactory uses of Monel metal is in seam-

less tubes for condensers and boilers for automobiles and motor boats. The metal draws perfectly into a smooth tube and its high elastic limit and tensile strength, combined with its incorrodibility, are of especial value in light machinery.

The largest casting so far made was a solid hub and propeller for the Southern Steamship Co.'s steamer *Creole*. This casting was 9 ft. 6 in. in diameter and weighed 6500 lb. It has given perfect satisfaction. Larger castings can be made, and as the material is much stronger than manganese bronze or Tobin bronze, it is eminently suitable for any purpose to which these have heretofore been applied.

In small cast propellers for hydroplanes or high-speed motor boats, the wheels are subjected to an enormous strain. The Hydroplane Co.'s engines turn from 1500 to 2000 r.p.m. at 40 hp. With a blade 16 in. long, 40 deg. pitch and the edge of the blade thinned down to 1/8 in. it requires an extraordinary metal to withstand the strain.

Under these conditions standard manganese bronze bends at the blade tip and becomes useless. Monel metal has been given exhaustive tests in such service and proves absolutely rigid and at the same time retains its original burnished surface.

Some of the physical constants of the metal, its electrical qualities, the effect of varying amounts of carbon, silicon, copper and iron, yet remain to be worked out. As these are investigated it is hoped to present a series of papers embodying further experience with this remarkable alloy.

Copper Cliff, Ont.

Deoxidation and Desulphurization in Electric Steel Furnaces.

By Dr. R. Amberg.

There are still people found who think that certain mysterious electric forces are active in electric steel furnaces.[1] As a matter of fact, any discrepancy of electric steel refining from the older metallurgical practice may be easily explained on the basis of well-known and generally-recognized principles and facts.

The extraordinarily high temperature may be considered the characteristic feature and one of the chief advantages of the electric furnace over the gas furnace. It is, therefore, interesting to compare the different systems of electric steel furnaces with respect to the degree and the distribution of the temperature within the same.

The Héroult furnace has two places of maximum temperature right below the lower ends of the two electrodes, where the arcs play between electrodes and slag. The temperature differences in the furnace cause a certain automatic agitation of the steel bath which is also influenced by the chemical reactions occurring at any moment in any place.

In the Stassano furnace the surface of the bath is heated by radiation from a central point above. Although the center of the surface gets hotter than the border, the temperature differences do not seem to be sufficient to provide the necessary agitation, since Stassano let his furnace revolve for just this purpose. The Bonner Fraeserfabrik has called my attention to the strong downward deflection of the arc, which is an essential factor in producing a sufficiently high temperature.

In the induction furnace any vertical section has a uniform temperature. Temperature differences are produced by special means, such as reducing the cross-section of the bath at certain places, or by additional "pole plates" as in the Roechling-Rodenhauser furnace. A rotation of the whole steel bath is automatically produced by the rotary magnetic field in polyphase induction furnaces.

Neither the Stassano furnace nor the induction furnace has any places of such a pronounced high temperature as the Héroult or Girod furnaces have right below the arcs.

The high temperature is of importance for two reasons. First, it increases the fluidity of the slag and of the steel bath and therefore facilitates diffusion and convection currents and consequently the chemical reaction between slag and steel bath. Secondly, the high temperatures cause a very high reaction velocity; at low temperatures an increase of 10 deg. C. generally doubles the reaction velocity and at the temperature of the steel bath in the electric furnace the reaction velocity is probably infinitely high.

From these viewpoints it is interesting to refer to the discussion of Gelsenkirchen and Osann (this journal, Vol. VI, p. 405). In the Héroult furnace the slag has the highest temperature and is therefore very fluid, so that the reactions in the slag occur very quickly. In the Roechling-Rodenhauser furnace the steel bath is the principal source of heat and gives off its heat to the slag. Reactions in the slag alone are, therefore, not as much facilitated in the Roechling-Rodenhauser furnace as in the Héroult furnace. On the other hand reactions between slag and metal will be facilitated if these reactions evolve heat so that more heat is supplied to the slag. This is indeed the case under the conditions of actual operation.

According to the Héroult patents the slag contains metallic sulphides and calcium carbide (the latter being either formed in the slag in the furnace or added). In the Roechling-Rodenhauser furnace Osann states that calcium carbide has not been found effective, probably because the temperature was too low. But if ferrosilicon is added to the steel bath in the Roechling-Rodenhauser furnace the reaction between steel bath and slag is facilitated by the greater fluidity of the slag due to the high combustion heat of silicon and the introduction of silica. Stassano also uses ferrosilicon.

The empirical formulas of the reactions by which sulphur is removed are as follows

In the Héroult furnace:

$$2\,CaO + 3\,FeS + CaC_2 = 3\,CaS + 3\,Fe + 2\,CO$$

and in the Roechling-Rodenhauser furnace:

$$4\,CaO + 4\,FeS + FeSi_2 = 4\,CaS + 5\,Fe + 2\,SiO_2.$$

The reaction which is at the bottom of these two processes is the change of FeS or MnS into CaS and appears to lead to an equilibrium, which is displaced by a small addition of metallic oxides toward the CaO side (i.e., so that the reaction of the following equation when read from right to left is increased):

$$CaO + Fe\,(Mn)\,S = CaS + Fe\,(Mn)\,O.$$

Hence a curve which would represent the desulphurization as function of the FeO content in the slag does not show any sharp break, but a gradual bent when FeO occurs. In parenthesis it may be mentioned that Osann's supposition of the reversal of the reaction $FeO + Mn = SFeS + MnO$ for 1350° to 1500° has already been proven by Schutz to take place in fact (*Metallurgie*, 1907, p. 669 to 6621).

In the electric refining processes, discussed above, any oxide is removed by the addition of reducing agents. Although both types of furnaces are built air tight and the metal bath is protected by the layer of slag, the Héroult furnace has the further advantage of a reducing atmosphere, due to the CO set free in the reaction and to the incandescent terminals of the electrodes.

The removal of sulphur in form of manganese sulphide is made more difficult in the Roechling-Rodenhauser furnace by the strong circulation of the bath, while in the Héroult furnace the conditions are more favorable for this reaction and the highly fluid slag permits the MnS to pass to the surface. But in both furnaces the removal of sulphur in form of manganese sulphide is of much smaller importance than its removal in form of CaS.

Finally the formation of silicon sulphide, suggested by Osann (see also M. Haff, this journal, Vol. VI, p. 961), is quite possible in certain stages of the process on the basis of thermochemical considerations, though such facts are not available. For instance, in experiments of the author (*Stahl und Eisen*, 1904, p. 304) such a strong evolution of SiO_2 has been observed from FeS and SiO_2 under the influence of an arc, that a direct evaporation of SiO_2 cannot be assumed.

[1] It is hardly necessary to discuss in detail the peculiar hypothesis of Schmid (this journal, vol. VI, 1908, p. 81), since so far he has not proven it by any facts. See also M. Haff (this journal, vol. VI, 1908, p. 961).

explanation of my experiments and of the process in the steel bath may be that ferrosilicon (which can always form under the condition of my experiments and which is added in the Rochling-Rodenhauser furnace) reacts with FeS in such a way that SiS_2 is formed, evaporates and oxidizes in the air.

Dortmund, Germany.

A Practical Note on Thermoelectric Pyrometers.

By Charles H. Wilson.

Those with an interest in pyrometers have, in most cases, come to know that of thermoelectric pyrometers there are two types. One is the Le Chatelier type, and it may be well to state here that Henri Le Chatelier is a French metallurgical engineer and scientist who has neither patented, manufactured nor sold pyrometers, but as a result of most careful and successful investigations has recommended a pyrometer with thermocouple of pure platinum and an alloy of 90 per cent platinum and 10 per cent rhodium, and a galvanometer of high internal electrical resistance; and in regard to this high internal resistance he expressed a preference for over 200 ohms; the object being that readings of the galvanometer would then be but negligibly affected by variations in the resistance in the thermocouple and leads as those are changed in temperature and length.

At the time when these recommendations were made Le Chatelier had to choose between galvanometers of the suspended-coil type which permitted the high internal resistance of from 200 to 400 ohms and double-pivoted millivoltmeters of from 2 to 4 ohms.

Intermediate instruments of single-pivot and double-pivot construction have recently been perfected giving internal resistance superior to 75 ohms for the low millivolt range required in connection with Pt, Pt — Rh thermocouples, and these, while sacrificing very slightly the fine accuracy of suspended-coil instruments for pyrometer work, are so much better adapted for use under industrial conditions that they have carried what is practically the Le Chatelier type into works where the suspended-coil galvanometers could not go. That these 75-ohm pivot indicators, when calibrated for a definite external resistance approximating that of leads and thermocouple, are capable of a high order of accuracy, I shall later endeavor to show.

What are designated as "low-resistance pyrometers" have, during the last few years, come widely into use. They are the logical outcome of the discovery that, while thermocouples of certain alloys of base metals will not maintain their e.m.f., and, in some cases, not even withstand the physical and chemical assault of the very high heats that the platinum-rhodium couples will meet, they will, nevertheless, withstand the more moderate heats when such base metal couples are constructed with elements of large cross-section.

This large cross-section of the wire or tubular elements of a couple give it at the same time a very low electrical resistance. Consequently if it is low in resistance, say, 0.06 ohm, the change in resistance as the couple is used under conditions varying from being heated only at the tip to being heated throughout most of its length, may still be large in a percentage way, but will be small in the abstract. If it doubles in resistance the change will be only 0.06 ohm.

This is quite a departure from the platinum couples which are made in all diameters and lengths, but which are frequently of about 2 ohms at 72° Fahr., and which change to 4 ohms when heated to 2000° Fahr. throughout nine-tenths of their length.

In the case of the Le Chatelier type it is customary, speaking of industrial practice, to disregard the resistance in the leads as they form but a small percentage of the entire circuit, say, 1 or 2 ohms out of 300, but leads resistance should be, and generally is, carefully considered in the low-resistance pyrometers and it is further kept down to the small amount of 1/10 to 1/3 ohm.

With total resistance of leads and thermocouple of, say, ½ ohm, a millivoltmeter of, say, 4 ohms, and calibrated for ½ ohm external resistance, completes a low-resistance pyrometer.

Now let us see the degree of accuracy that may be expected, based solely on the matter of intended electrical resistance in the entire circuit.

In the Bureau of Standards Circular No. 7, 3d edition, Oct. 1, 1908, is published a simple proportion expressed in this formula:

$$E_1 = E\,\frac{R_2}{R_1 + R_2}$$

where E = true electromotive force of a thermocouple for any assumed difference of temperature between its junctions.

E_1 = actual reading in millivolts on millivoltmeter or galvanometer.

R_1 = all resistance of thermocouple wire and attached leads not allowed for in the calibration of the instrument.

R_2 = resistance of the galvanometer or millivoltmeter.

Let us take a Le Chatelier type of pyrometer of which a fair example would be

$R_1 = 3$ ohms, composed of leads, 1 ohm; couple, 2 ohms.

$R_2 = 200$ ohms

Then $E_1 = E\,\frac{200}{3 + 200} = 0.985\ E.$

That is to say the reading on the instrument would be 1½ per cent low when the couple is heated only at the junction.

The same pyrometer with the couple heated through most of its length to about 2000 deg. F. would have

$R_1 = 5$ ohms, composed of leads, 1 ohm; couple, 4 ohms.

Then $E_1 = E\,\frac{200}{5 + 200} = 0.976\ E.$

That is to say, the reading would be 2.4 per cent low.

Let us next take the same couple and leads with a 75-ohm, single-pivot indicator calibrated for 3 ohms external resistance, which means that the 3 ohms are not an outside factor, but become an integral part of the resistance of the galvanometer, i. e., $R_2 = 75 + 3 = 78$ ohms. When leads and couple are cool, except the tip of the couple, there is *no* resistance in either leads or couple not taken care of in the calibration and $R_1 = 0$

$$\therefore E_1 = E\,\frac{78}{0 + 78} = E.$$

In other words we should here have a true reading. But let there be no misunderstanding of the reason why with the couple cold throughout most of its length we obtain a truer reading with the 75-ohm than with the 200-ohm galvanometer. It is because I have assumed conditions of actual practice where the higher-resistance galvanometer is calibrated without reference to the resistance of couple and leads, while the 75-ohm instrument we are considering is calibrated for the actual resistance in the couple and leads, with the couple cold.

Let us now consider the 75-ohm galvanometer with the couple heated throughout most of its length to about 2000 deg. F.

R_2 remains $= 75 + 3 = 78$ ohms as before, but the increase in resistance of the couple from 2 to 4 ohms is 2 ohms, so $R_1 = 2$.

Then $E_1 = E\,\frac{78}{2 + 78} = 0.975\ E.$

That is, the readings would be 2½ per cent low, or practically the same as with the 200-ohm galvanometer calibrated in true e.m.f.

In a "low-resistance pyrometer" the resistance of the millivoltmeter will be, say, 4 ohms; of the couple when cold, 0.06 ohms; and of the leads, 0.34 ohms. Here, of course, the calibrations will take into consideration the resistance of couple (cold) and leads, so

$$R_2 = 4.00 + 0.06 + 0.34 = 4.4 \text{ ohms.}$$

If the couple when heated so much as doubles its resistance we shall have $R_1 = 0.06$.

Then $E_1 = E \frac{4.40}{0.00 + 4.40} = 0.9860\ E$.

That is, the reading will be about 1 1/3 per cent low, and if the couple were heated only at the tip there would be not even that small error.

But let us see the result of combining a millivoltmeter of the general type employed in the low resistance pyrometers with a platinum platinum-rhodium thermocouple 3 ft. or 4 ft. long. To begin with, the electromotive force of the platinum couple is so much lower than that of the base-metal couples that to obtain full scale deflection with the former the resistance of the indicator would have to be cut to at least 2½ ohms—this is a matter of instrument construction, and I do not refer to the single-pivot and double-pivot indicators used in the modified forms of the Le Chatelier pyrometer.

To give this combination every possible advantage we will assume that it is calibrated for an estimated resistance in leads and thermocouple, which will be, say, ½ ohm in the leads and 3 ohms in the couple, or 3½ ohms in both. As the couple under different conditions of use will vary from 2 to 4 or perhaps 5 ohms, it will readily change its resistance from whatever is assumed by at least 1 ohm.

So $R_1 = 1$

$R_2 = 2\frac{1}{2} + 3\frac{1}{2} = 6.$

Then $E_1 = E \frac{6}{1 + 6} = 0.857\ E$

That is, the readings will be from 14⅓ per cent high, to the same amount low, or at 2000 deg. F. an error of 287 deg. F. must reasonably be expected except by calibration of the pyrometer with an exact knowledge of the length of couple, its depth of immersion into the heated zone and the approximate heat of the thermocouple wires where immersed.

This should answer the question that has been so often asked: Why cannot one use a platinum-rhodium thermocouple on the indicator of a "low-resistance pyrometer"? The low-resistance pyrometer and the high-resistance pyrometer are each capable of accuracy, but the mistake of uniting the thermocouple of the latter with the indicator of the former must not be made. If one indicator is needed on both platinum and base metal couples it must be the high-resistance indicator of surely not under 50 ohms.

The influence of change of resistance in the leads and the introduction of contact resistance may be estimated in the same way and it will be seen on doing so why the low-resistance pyrometer should have electrical connections soldered where possible.

Peat and the Production of Power.*

By Herbert Philipp.

The greatest future for the extensive use of our peat bogs lies in the conversion of peat into energy for industrial purposes, either by establishing central power plants at the bog and distributing electrical energy from this center, or for industries to locate near enough to the bog to prevent the encumbrance of any unnecessary cost by the transportation of the peat.

It is barely two decades ago that the industry of Europe considered it impossible to use peat as a fuel as long as the price of coal did not exceed $2.50 per ton, and hitherto the employment of peat as fuel for power generating purposes has been insignificant. The reasons that peat has found so little use here in North America are not because of its poor heating value, which is somewhat compensated for by the facility of procuring same, but because of the large number of failures of concerns who intended to manufacture peat for fuel purposes, their failure being due to the ill-advised large speculation into processes which were mere laboratory experiments, the want of peat drying processes of economic value or processes for using it wet, and the gasification of peat. This large number of failures made capitalists suspicious of investing in peat factories, and they were afraid to invest one cent in peat interests. However, now that in Europe such successful results are being produced, more general interest is being shown for the development of the bogs and the conversion of peat into power.

The peats found in the different bogs vary extensively and also the results obtained from same are just as variable.

Peat in the bog can contain moisture up to 90 per cent, and the separation of this large amount of water from the peat has formed one of the drawbacks in making use of peat. To-day there are several very efficient and cheap processes in use for drying peat, yet air-dried peat seldom contains less than 15 to 20 per cent free moisture, depending very much on the climatic conditions. Further drying of the air-dried peat can be accomplished by using the sensible heat in the formed gas in cases where peat is gasified, or in the flue gases where peat is used under boilers.

The ash in peat forms also an important item and is very variable, often so in the same region, and there are also equally great differences in its composition. It is rare that peat-ash represents merely the mineral constituents of the plants from whose remains the peat has been formed. It contains also mineral matter carried by the water, mechanically or chemically, which permeates the bog, and the composition of the ash is also generally influenced by the nature of the prevailing rocks in the neighborhood of the peat deposits.

To illustrate the varying ash content of peat, the following figures might be of interest: In Wood of Allen, Ireland, the peat contains 2.0 to 8.0 per cent ash. Mulder reports peat in Friesland, Germany, as containing 1 to 4 per cent ash. Peat of Baden, Germany, is reported by Petersen to contain 0.9 to 14.8 per cent ash. Maisilly states that peat from Department d'Oise, France, tests 6.7 to 14 per cent ash. In New Jersey, within 30 miles from here, there are several peat deposits which could be used for fuel purposes, testing 5 to 15 per cent ash. This ash content is very important in determining the value of a peat deposit for fuel purposes, and it is always desirable to make a large practical test for the ash in investigating a peat bog for its value as a fuel.

The composition of the ash varies greatly, as has been stated, yet in the majority of the fuel peats which have come to my attention the ash contains 80 to 90 per cent silica, traces of sulphur, except from salt water peats, which generally contain large quantities of sulphur, also alumina and small quantities of lime, showing that there is very little in the ash to form clinkers.

In determining the calorific value of peat it is better to make direct determinations in a calorimeter than to rely on Dulong's formula, as determinations by this formula invariably give results 6 to 10 per cent too low.

We have two distinctive ways in using peat for power and heating purposes, firstly, by firing peat direct under boilers or into furnaces, and, secondly, by gasifying peat.

For direct firing peat is used in large fist-size pieces or in the form of briquettes. Peat which disintegrates very much on drying has to be briquetted, especially if it has to be transported any distance from the factory, which is done without any additional binder and at a very low cost. In cases where the peat disintegrates and dusts easy, it can be, if used at the factory, effectively burned under a boiler by a powder-firing apparatus.

For firing on grates several characteristic properties of peat have to be taken into consideration. Peat is specifically much lighter than coal, and requires more work to keep an efficient heavy fire bed than when coal is used. This also increases the labor for hand firing, not only because the heating value of the peat is slightly less than coal but on account of its bulkiness

*A paper read at the meeting of the New York Section of the American Peat Society, Feb. 13, 1909.

one man cannot fire the same amount of peat in a given interval as he could coal. These difficulties are overcome by using a step-grate with mechanical feeding, as is stated below. The grate bars on an ordinary grate have also to be placed closer together, because peat ash does not generally clinker and the ash would fall into the pit too easily and then the burning peat which disintegrates easily, would fall through and a considerable loss would be sustained by the unconsumed carbon in the ash.

The step-grate is very decidedly more economical for the firing of peat direct under boilers, or even for the direct firing of open furnaces, and the addition of apparatus for the mechanical feeding of peat can be used more effectively than with the plain grate; neither is there so much loss of heat sustained by unconsumed carbon falling through the grate bars, yet the loss of heat in the ash is as great as in the other.

The moisture of air-dried peat for fuel purposes is on an average 15 per cent, and in Sweden[1] practical use of the sensible heat of the flue gases is made to expel more moisture. In Timsfors and also in Rydboholm the flue gases circulate directly around the peat in a specially constructed oven. In bad weather, when the chimney draft is poor, fans are used to draw the off gases through. It is best to have two such ovens, which are then used alternatively.

Peat briquettes generally show a slightly higher value in heat units than the unbriquetted peat. Samples of American peat fuel with 12 to 18 per cent moisture have shown 9000 to 10,000 B.t.u., and if the peat is dried better by artificial means it shows 10,500 to 11,500 B.t.u. and over. This is very favorable, as coal used for industrial purposes has generally only from 12,000 to 13,000 B.t.u. Taking into consideration the low price per unit that peat costs when used at place of production, it fully compensates for the missing heat units.

Of course, enough peat has to be dug up in the seven or eight working months to keep a power plant fully supplied for the balance of the year; this is rather a drawback as it necessitates the erection of large storage sheds to house the peat in. One thing is of interest in regard to the storing of peat, and that is that a pile of peat does not suffer from the possibilities of spontaneous combustion as is the case in storing coal.

We now come to the **gasification of peat,** which can be divided into two chapters: Dry distillation of peat (external heating), and, secondly, the gasification of peat by internal combustion.

The **dry distillation** or coking of peat was tried very many years ago, but failed on account of the peat-coke being too soft for metallurgical uses. The Swede Ekelund was the first one to obtain the condensation products from dry distillation of peat and to use the distillation gases for heating purposes, but owing to the poor grade of coke he obtained and fluctuating prices of the condensation products, he did not follow his work any further.

A few years later the German, Martin Ziegler, started practically the same process as Ekelund had given up, but through his previous experience with soft-coal distillation and more perseverance he has built up a successful and practical process. Ziegler obtains a hard coke, which finds use in metallurgical processes, by using a very dry peat briquetted under high pressure; and all of the condensation products are purified or used as raw materials in other processes. The uncondensed gases are used for heating his retorts.

Although Ziegler deserves much credit in achieving success in the distillation of peat, it can hardly be considered as a factor in the production of power from peat. Yet the production of coke in conjunction with a gasification plant by internal combustion would form a plausible and practical possibility.

I shall now pass on to the very important and interesting subject of the gasification of peat by internal combustion.

The gasification of peat by internal combustion can also be classified under two heads: The production of producer gas from dry peat, and the production of producer gas and ammonia recovery from wet peat.

The production of **producer gas from peat** is not so very new, as since about 1872 the Moltala Steel Works, in Sweden, have been using producer gas made from peat. The peat gas costs them somewhat more than coal gas would, owing to the fact that same has to be transported across Lake Wetter in sailing vessels and then by railroad to the works, but on account of the negligible amount of sulphur and phosphorus present they find it desirable in their open-hearth and puddling furnaces. In their rolling mill it is especially noted that thin steel plates scale less when fired with peat gas.

The making of peat producer gas is governed by similar laws and rules as in the manufacture of producer gas from coal. There are several well-known systems for gasifying fuel which differ chiefly in shape and in position of air and steam inlets. In producing this gas from peat we require a large fuel bed, varying in size from 5 ft. to 8 ft., according to the specific gravity and size of peat used.

The size of the peat should not be too big and it does not harm if it disintegrates, as long as it does not become too dense to prevent the steam, air and formed gases from passing freely through the firebed. In fact, the finer divided the fuel and the greater the depth, the more favorable are the chances for the formation of a high per cent of carbon monoxide. In cases where fuel-beds of necessary depth cannot be obtained, or where peat with low specific gravity is used, the formation of carbon monoxide can be enhanced by reducing the velocity of the gases; in other words, by a weaker draft and blast, thus prolonging the contact of the gases with the fuel-bed.

The air and steam entering the producer come in contact with incandescent peat and form carbonic acid and hydrogen. The heat generated by this reaction is taken up by this mixture of gases, which heat again is absorbed by the peat above this incandescent zone. The carbonic acid and hydrogen are converted into carbon monoxide, and partly methane, by the glowing carbon. The top zone is, however, hot enough to liberate and decompose many of the condensible peat products into combustible gases. We, therefore, find olefiant gas in peat producer gas.

The peat gas from the producer has still a high temperature, and this sensible heat can be very valuably used by further drying the air-dried peat, which is being fed to the producer. This can be accomplished either by bringing the peat directly in contact with the gases as it is uniformly fed into the producer, or by indirectly circulating the hot gases round ovens constructed of sheet iron.

Points for the efficient working of a peat-gas producer are a high temperature in the first 3 ft. or 4 ft. of the fuel bed, regular feeding of the peat, feeding the correct proportion of steam and a good air blast, both of these latter at a low pressure.

A good average peat gives 40 cu. ft. to 45 cu. ft. producer gas per pound of peat (dry), with a heating value of 160 to 200 B.t.u. per cubic foot.

I now arrive at the gasification of wet peat. Some two or three years ago, at the instigation of Mr. Mond of England, Frank and Caro undertook the study of **the gasification of wet peat** in the Mond producer **and the recovery of the** peat nitrogen content as **ammonia.** Satisfactory results have been obtained in these producers in England, Germany and France; and Woltereck reports, by a similar process, to have also obtained good yields.

Inasmuch as descriptions of these processes have been extensively published, I shall not go here into details. Peat containing 50 to 55 per cent water is used and in the tests carried out at Stockton and Winnington 70 per cent of the nitrogen in the peat was recovered as ammonium sulphate.

The favorable results of Frank and Caro have already in duced capitalists to erect a Mond gas plant for peat gasification and ammonia recovery at Herne, in Westphalia, Germany.

[1] Sche ber. Oest Moorztsch. 1908, p. 161.

The plant at Mont Cenis colliery, in Westphalia, has been designed and erected by the Power-Gas Corporation, Ltd., of England, who have been experimenting for many years to apply the Mond process to the gasification of peat. The success which has marked their endeavors has been so favorable that three installations are now nearly completed: one in the County of Norfolk, England; one in Italy and the third in Germany. Results, which they have published, state that the peat with 40 to 60 per cent moisture was used, and per ton of dry peat, containing 1 per cent nitrogen, gasified, they obtained about 80 lb. sulphate of ammonia; 80,000 cu. ft. to 85,000 cu. ft. of good power gas, testing 150 B.t.u. per cubic foot.

Another large installation for the gasification of peat and recovery of ammonia, by this same process, is now in course of erection in the northwest of Germany. This central generating plant, which controls about 16,000 acres peat land, intends to distribute electrical energy over a wide area for agricultural purposes, as also for the provision of light and power in a number of towns situated within a radius of 40 to 50 miles from the power plant.

It is estimated that by means of the large gas engines work to the extent of 600 hp-hours will be obtained from each ton, while the value of the ammonia recovered is estimated to yield a good interest on the investment.

The vast peat resources in North America are undoubtedly well known to all, and the fact that many of the deposits are situated where the price of coal almost demands their utilization to-day should stimulate capitalistic judgment into developing this profitable industry for their own and the public's benefit.

I should still like to mention that the majority of peat deposits in North America show a higher heat value than the European deposits are reported to have, so that we can only look forward to more favorable results than are obtained abroad.

Reduction of Refractory Oxides, Production of Ferro-Alloys and Formation of Carbides.

Several interesting electric-furnace researches have recently been carried out at the Electrochemical Laboratory of the University of Manchester at the suggestion of Dr. R. S. Hutton. While the complete accounts of these researches may be found in a number of papers by H. C. Greenwood, R. E. Slade and J. N. Pring, in the *Transactions* of the (British) Chemical Society, 1908, vol. 93 (pages 1484, 1496, 327 and 2101), the following summary of the results obtained will prove interesting.

The object of the first research of Mr. Harold Cecil Greenwood was to determine the temperatures at which carbon begins to reduce some of the more difficultly reducible metallic oxides. The mixture of the oxide with carbon was heated in an electric tube furnace. Temperature measurements were made with the Wanner optical pyrometer.

The temperature at which reduction commenced was gaged by the commencement of the evolution of carbon monoxide from the mixture of oxide and carbon. A serious difficulty was encountered due to gas which is occluded by the carbon, and which is gradually given off as the temperature is raised. It was found, however, that if the temperature were raised in small steps and maintained constant for some time at each, the increment of pressure due to occluded gas in a given time was practically constant for different temperatures.

The method for estimating the rate of gas evolution finally adopted and followed in all the experiments consisted in maintaining the tube at a constant temperature for five minutes and observing the rise of pressure during the interval. At the end of each interval the pressure was reduced by rapid evacuation during the next minute and the temperature then raised to another value, at which it was maintained for five minutes, and so on.

The rate at which gas is evolved from the carbon depends, first, on the difference in temperature between each step, and, secondly, on the length of time the carbon has been maintained at a constant temperature. Of course, the increase in pressure on raising the temperature is to some extent due to expansion as well as to the actual gas evolution. This effect, however, is approximately constant for each temperature step, and is only small, as to the average temperature of the gas probably does not exceed 200° when the carbon tube is heated to 1500°.

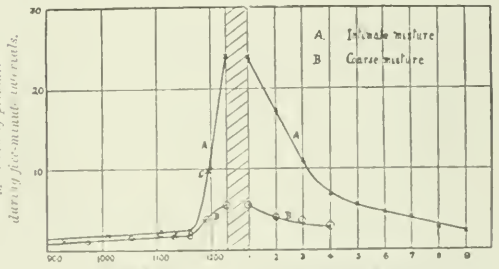
When the reduction temperature of the oxide is attained the gas evolution shows a marked increase.

When the temperature is maintained constant a little above the reduction point the gas evolution gradually dies away on account of the decrease of contact surface as reduction proceeds. As regards the fixing of the temperature at which reduction commences, the following convention was used: If there be a sharp jump from a pressure rise of, say 2 mm in five minutes to one of 10 or 20 mm, the reduction temperature is taken as the mean of the two temperatures; but if at three successive temperature steps the rises in temperature are such as 2, 5, 15, then the middle temperature is taken as that of initial action. With temperature steps of 20 to 30°, this method gives quite concordant results.

The oxide most carefully studied was **chromium sesquioxide.** Some preliminary experiments showed that reduction commenced at about 1200°. The material used was Merck's "extra pure" chromium sesquioxide, which was intimately mixed with a good quality retort carbon in approximately the theoretical proportions. The reduction temperatures estimated from three careful experiments with these materials were 1180°, 1185°, and 1195°, respectively.

The product contained small globules of metallic appearance, fairly uniformly distributed through the cross-section of the central portion. Quantitative reduction was never obtained on account of the limit to the intimacy of admixture attainable with retort carbon (the temperature not being taken much above the reduction point).

With an intimate mixture of chromium sesquioxide and retort carbon the temperature was gradually raised to a value slightly above the reduction point (to 1230°) and maintained constant there, the increments of pressure during successive five-minute intervals being noted. The way in which the rise of pressure increases and then falls off is shown in the adjoining illustration (Curve A).



DETERMINATION OF REDUCTION TEMPERATURES

Another experiment was next carried out under exactly similar conditions with a mixture of chromium and sesquioxide and coarse retort carbon in the same proportion as before.

In this case the pressure began to rise at about the same temperature, but the extent of the reaction was much more limited. Even on afterward raising the temperature to 1300° the gas evolution was small. The great influence of this intimacy of mixture is shown in the illustration, and would seem to point to several important conclusions.

The temperature at which the gas begins to be evolved is that at which reduction by carbon takes place, and is not a mere process of dissociation.

Further, the falling off of the gas evolution and the incompleteness of the reduction is due to the decrease of contact surface between oxide and carbon. In the experiment with the coarse carbon the reduction could be very plainly seen to be limited to the actual surface of the carbon granules, which were coated with a metallic mirror. This last fact also indicates that the reduction is really effected by carbon, and not by any hydrogen or carbon monoxide present.

The chief results of the investigation carried out in this way are as follows:

It is shown that the reduction temperatures of the oxides of **chromium** (1185°), **manganese** (1105°), **uranium** (1490°), **silicon** (1460°), **zirconium** (1400°), and **thorium** (1600°), by means of carbon, are far below those which are generally supposed to be necessary for the production of these metals from the oxides.

These reductions commence very sharply at a given temperature, but the progress of the reduction depends greatly on the intimacy of contact, and thus on the degree of subdivision of the oxide and carbon.

The reduction temperature is found to alter on using different varieties of carbon. In some cases differences are also indicated between samples of the oxide prepared under varying conditions, but the effect can be shown to be due to the physical state of the oxide.

In all the cases studied the reaction takes place long before the melting point of the oxide is reached, and the product of reduction is also in the infused state.

Experiments to measure the temperature of dissociation of these oxides indicate that they are extremely stable (even in a high vacuum) up to temperatures far exceeding the reduction point by carbon.

* * *

The reducibility of **magnesium oxide** by carbon was the object of an investigation by Mr. Roland Edgar Slade. His research seems to prove satisfactorily that magnesia is reduced by carbon, not only at the high temperature of the electric arc, but as low as 1700°.

Watts (Trans. Amer. Electrochem. Soc., 1907, 11, 279) mentions the fact that carbon can be volatilized from a bed of magnesia, and he obtained sublimates consisting of intimate mixtures of magnesium oxide and carbon.

Slade's work shows clearly that the metal can be isolated, although under ordinary conditions re-oxidation of the magnesium is effected by the carbon monoxide, for if some device is used for removing this gas, for instance, by working in a vacuum, by absorption of aluminium, or by a rapid stream of hydrogen, then metallic magnesium is obtained. The condensed magnesium is always associated with small quantities of a carbide, which, on treatment with water or dilute acid, gives off acetylene.

* * *

The well-known effect of the presence of other metals in the reduction of refractory oxides by means of carbon for the **manufacture of ferro-alloys** has been the subject of a second investigation by Mr. Harold Cecil Greenwood.

While it is very difficult to produce elements such as chromium and silicon by direct smelting of the oxides, the production of ferro-alloys from a mixture of the oxides with ferric oxide is a comparatively simple matter. To account for this behavior several causes can be suggested: the greater fusibility of the alloy, or the local increment of temperature due to the oxidation of carbon by the ferric oxide, or some definite chemical affinity between the two metals. Some experiments conducted with silica led to a somewhat lengthy investigation of the problem.

Influence of Iron in the Reduction of Silica.—A preliminary experiment, using a mixture of purified sand, retort carbon, and electrolytic iron powder in the proportion 20:8:30, respectively, indicated that the reduction commenced at a much lower temperature (about 1200°) than with silica and carbon alone (1460°). This fact seemed so striking that the matter was closely investigated.

The experiments of the author leave no doubt that the presence of metallic iron exercises a remarkable influence on the reaction between silica and carbon. The exact temperature at which action commences is, as might be expected, not so sharply defined as in the simple reduction of an oxide. The experiments also point to the conclusion that in the reduction of a mixture of the oxides of iron and silicon the influence of the iron is exerted after reduction (which takes place at a comparatively low temperature), and not through the heat developed in the process.

Influence of Ferric Oxide on the Reduction of Silica.—With the idea of gaining more light on this point, an experiment was carried out with a mixture of silica, retort carbon, and ferric oxide. The temperature having been raised to 1130°, the product was heated in chlorine, when only a slight turbidity due to silica was obtained. This would indicate that ferric oxide does not exert any appreciable influence on the reduction of silica before itself undergoing reduction. The fact that the reduced iron had produced so little reduction was probably due to its poor contact with silica.

Effect of Metallic Manganese on the Reduction of Silica.—The effect of metallic manganese was also investigated. With an intimate mixture of purified sand, retort carbon and metallic manganese (free from aluminium and sodium) reduction commenced pretty sharply about 1100°, the temperature being raised to 1200°.

Effect of Copper on the Reduction of Silica.—It was hoped that by using a mixture of purified sand, retort graphite, and copper powder, it might be possible to collect any silicon formed by its solution in the molten copper. Reduction commenced at about 1250° and the temperature was raised as far as 1340°. The result, however, was disappointing, as the copper had not fused together, but a gray residue was left which was attacked only with difficulty by nitric acid, the copper having probably formed silicide.

Referring to the three suggested causes for the influence of the presence of ferric oxide on the reduction of oxides by carbon, these experiments seem to show that local raising of temperature by reduction of ferric oxide does not play an important part. Probably direct affinity between silicon and the metal accounts for a good deal of the action, especially as the products (with iron, copper, and manganese) were only difficultly fusible.

Influence of Iron on the Reduction of Chromium Sesquioxide.—The above experiments with silica led to an investigation in a similar way of some other oxides from which ferro-alloys are produced technically. Starting with chromium sesquioxide, a mixture with retort carbon and metallic iron (electrolytic powder) was taken. Contrary to the experience with silica, the mixture behaved just as if iron were absent, giving a sharp reduction point of 1190°.

Effect of Ferric Oxide on the Reduction of Chromium Sesquioxide.—On the supposition that ferric oxide might have some specific action, an experiment was performed, using a mixture of retort carbon with ferric oxide and chromium sesquioxide, the temperature being raised to 1130°. Curiously enough, the residue was yellowish-brown and was unaffected by acid (except for the metallic iron present) and by boiling with permanganate. Thus it was not found possible to isolate the metallic portion (which, moreover, seemed to be present only in small quantity). Probably what had happened was that ferric oxide was first reduced to ferrous oxide, which combined with chromium sesquioxide to form the brown spinel (FeO, Cr_2O_3), only the excess of ferrous oxide being further reduced to metal.

Judging from these experiments, neither iron nor its oxides

facilitate the reduction of chromium sesquioxide below its ordinary reduction temperature. At higher temperatures the solvent action of the iron may have some effect in preventing re-oxidation.

Effect of Metallic Manganese on the Reduction of Chromium Sesquioxide.—Using instead of iron a mixture of metallic manganese with chromium sesquioxide and retort-carbon, reduction seemed to commence about 1120°. The temperature was raised to only 1150°, but the residue on examination appeared to contain very little unreduced chromium sesquioxide. Another experiment in which the temperature was raised to only 1140° gave a similar result. On extracting the metallic portion by boiling with permanganate and treating as in the iron-chromium oxide experiments, the product appeared quite free from chromium sesquioxide under the microscope, and dissolved in hydrochloric acid to a bright green solution, evidently containing a high percentage of chromium.

There is, then, little doubt that the presence of metallic manganese to some extent facilitates the reduction of chromium sesquioxide by carbon.

Effect of Iron on the Reduction of Manganous Oxide.—On heating manganous oxide (the oxide reduced in pure hydrogen being used) with retort carbon and electrolytic iron, the gas evolution became very marked at 1030°; the temperature was raised to 1055°. The metallic portion, which had slightly fused, was isolated by washing with dilute sulphuric acid, when manganous oxide is much more easily attacked than the metal. The residue under the microscope appeared quite free from any green oxide, and on testing gave the reactions of manganese. In this case, then, iron appears to exert some influence on the reduction.

The alloys formed by chromium and manganese with iron are more fusible than the silicon alloys, so that the part played by the solvent action of the iron may be rather greater than with silica

* * *

The formation of carbides has been the subject of an investigation of Mr. John Norman Pring.

In view of the fact that the carbide-forming elements are, in many cases, known to react with carbon monoxide and other carbon compounds, considerable discussion has recently been evoked as to whether these elements can combine directly to form carbides in the absence of such gaseous impurities.

This question has now been cleared up by Mr. Pring for silicon, aluminium, iron, and magnesium. The chief results are as follows:

Silicon.—The direct union of pure silicon and carbon in a vacuum commences between 1250° and 1300°, the reaction proceeding rapidly above 1400°.

Commercial silicon containing 5 per cent. of iron and 0.7 per cent of aluminium reacts with carbon at all temperatures above 1200°.

The presence of iron does not apparently facilitate the reaction, nor does carbon monoxide exert any influence between the limits of atmospheric pressure and 0.03 mm; hence, already below its melting point, silicon is proved to combine with carbon.

Aluminium.—This element unites directly with pure carbon in a vacuum at its melting point (650°), forming aluminium carbide (Al_4C_3), and the velocity of the reaction increases with the temperature, proceding rapidly above 1400°.

Iron.—Direct union with carbon occurs at about 700° under a pressure of about 0.05 mm.

Magnesium.—Evidence is forthcoming to indicate the formation, to a limited extent, of a new carbide below 600°, this compound giving some saturated hydrocarbon (probably methane) on decomposition with water or acids. At higher temperatures the reaction apparently ceases. This unstable compound is probably Mg_2C, of an analogous nature to Al_4C_3; the only carbide of magnesium, MgC_2, hitherto known corresponds with the carbides of the alkali and alkaline earth metals.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From our Special Correspondent.)

The Faraday Society.

In the discussion of Mr E. A. Ashcroft's paper, on Dec. 21, 1908, on "The Influence of Cheap Electricity on Electrolytic and Electrothermal Industries," Mr. W. R. Cooper maintained that the cost of water power was determined by its market price and was not likely to have a fixed value. The price of water power not being always commensurate with its value, such power should be purchased outright and not merely leased.

Mr. Bertram Blount considered that other sources of power, although more costly, had, under some circumstances, very great advantages, and the idea that power at a very low cost was essential for all electrochemical industries was not correct. There is much national selfishness abroad which impedes industries. The electric distillation of zinc will come; and the low cost of energy is of less importance than the economy of applying it. This paper had been based on the calculation of the cost of power. For the prosperity of an industry he thought that a preferable method of treating the subject was to have the thing under one hat rather than to have a power company and a user.

Mr. W. Murray Morrison thought that steam power could be had at a very much cheaper rate than that stated by the author, and that labor charges had been understated. No engineer would dream of putting capital into a scheme at £168 per electrical horse-power. Moreover, when capital charges were low, depreciation was high. Labor troubles and freightage, too, demanded consideration. Every scheme differed in some respect from another, and each must be considered on its merits.

Mr. Leon Gaster said that water power at Niagara was dear because only a small part of the power could be utilized. The cost of a gas or oil plant depended on its size. He deprecated the attitude of the Norwegian government toward foreign capital.

Mr. Charles Weiss considered that the conditions of the development of water power in the highlands of Bavaria were of considerable interest.

Mr. H. Borns pointed out that inconstancy of supply was only one of the disadvantages of water power.

Prof. H. Smith referred to frequent difficulties caused by ice. He was of opinion that the author's figures both for power and for depreciation were understated.

Dr. E. Feehmann thought that peat fuel might supply the means of effecting very cheap power-gas schemes. Experiments on a large scale were being made on this question.

Mr. E. A. Ashcroft replied that his chief object had been to point out that especial sources of water power were still, although not frequently, to be acquired, and to compare the different means of producing power. He maintained the accuracy of his figures. There were no troubles from ice in Norway.

Some remarks on the subject of water power by Mr James Swinburne in his presidential address to the Institution of Electrical Engineers, in December, 1902, are deserving of reproduction. He said: "Ricardo's theory of rent is applicable to water power as well as to arable land. If steam power costs a farthing a unit and if water power at the same place can be produced for half a farthing, after paying working expenses and interest, the owner of the water power will claim the odd half farthing as rent, or will just allow the water power enough to encourage the production of a new thing. As a rule, however, a water power is not where it is wanted industrially * * * The result is that water power cannot command the same price as steam or gas. * * *

"As a matter of fact, the cost of power is a much smaller item in most industries than is generally supposed, and it does not pay to start a works in an otherwise not perfectly suitable locality simply for the sake of cheap water power * * *

As to the cheaper power we have to put extra carriage for material and for coal—which is often needed in addition—and extra carriage for finished products, and very often extra cost of labor, as labor is often dear and bad in water-power districts. Let us take, as an example, calcium carbide. The general idea is that the electrical energy is practically the whole cost of the carbide. Taking present practice, however, a kilowatt makes, say, two tons of carbide a year. The difference between power at, say, £2 10s. and £5 a kw-year is thus £1 5s. a ton in cost. The price of carbide may be taken as £13 10s. per ton; so, doubling the cost of power instead of nearly doubling the price of the carbide would increase it a little more than 10 per cent.

"In the case of electrolytic caustic and bleach * * * for one ton the electrical energy taken at £2 10s. per kw-year—a low water power cost comes to about 17s. 6d. The caustic and bleach sell for about £20. Doubling the price of power, therefore, increases the price some 5 per cent. For a water power to be really valuable it should be near a source of material, on the sea, and should have a great head of water so that the capital cost of development is small. Such a water power is very valuable *to the landlord*. A blast furnace is more valuable than a water power. There are plenty in England. But the owners who have been wasting the gas up to now will not give it away; they will want rent, so that it will only just pay to use their gas rather than make it. The electrical industry thus does not gain, but the ironmasters do."

THE ROYAL SANITARY INSTITUTE.

The Purification of Water by Ozone.

On Jan. 13 Dr. Rideal read a paper on this subject before a full meeting. He described how the ozone process after early experiments had been employed at Berlin, Wiesbaden, Paderborn and Nice, and later installed at the St. Maur municipal water works, supplying Paris, were the De Frise ozonizer is being used.

The discussion was opened by Prof. H. Robinson, who said he thought Dr. Rideal did not appreciate the comparative conditions of London and Paris. Paris water was very impure; and it was not possible to compare St. Maur water with Thames water. Additional works would be required, as in the case of London it was a matter of quantity rather than of quality, this being satisfactory. It was entirely a question of efficiency and cost. Hitherto nothing had been done with ozone in England, but there might be a better opening in the future.

Col. Davis remarked that suspended matter caused waste of electrical energy, and filtration was necessary, which—it was agreed—required minute supervision. A process was wanted which did not require much attention.

Mr. A. J. Martin said that no process could go on without supervision. Bacteriological examination was necessary. Gas was constantly examined. How much greater was the need for examination of water? He asked the annual cost of working the plant, if filtration could be dispensed with, and if the apparatus could be readily installed in case of urgency.

Dr. Nash (Medical Officer of Health for Norfolk) thought that Dr. Rideal's experiments should be repeated, and when confirmed should be considered by water authorities.

Mr Eason Devonshire, chairman of Antwerp water works, stated that the St. Maur water was not supplied in bulk for Paris. The filters were not used regularly, but only for experimental purposes. Conditions for analyses required standardization. Water kept for a long time showed an immense increase in the number of bacilli and Paris water was sometimes stored for 15 days as against two days for London. The water from the Ivry works was practically sterile; there were no B coli in 1.00 cc. The spring-water supply of Paris had caused typhoid epidemic and contained three times as many microbes as the river water, yet there was prejudice against river water. Ozone changed the color of river water to that of spring water.

Mr. Aglio Dibdin remarked that the Otto process obtained the first prize at Paris in 1908, and it was proposed to install apparatus to sterilize 10,000,000 gal. per day so that with this and the De Frise installation a total of 20,000,000 gal. per day would be dealt with. There were already 10 Otto installations at work on the Continent. It was impossible to thoroughly test all the water entering the London mains, and Dr. Houston had not found typhoid germs in London water.

Mr. E. B. Barnard (chairman) did not propose to ozonize the London water and so increase the cost, although he quite appreciated the utility of the process in an emergency. Its cost would be £250 per day, or £90,000 a year. He regarded the present water supply of London as a refined article. Water was purified by storage in the reservoirs. The health of London was good, even if we could not meet the wishes of some people as to analytical details.

Mr. H. C. H. Shenton drew attention to the fact that the first announcement of Dr. Rideal's paper indicated that the purification of water by other chemical means would be dealt with; and he regretted that the author had not said anything concerning electrolytic hypochlorite. Dr. Rideal was the only person present who could speak from experience on this subject, but conclusions and deductions can be drawn from results he obtained at Guildford and Maidenhead 12 years ago. Chemically prepared hypochlorite was not nearly so efficient as the electrolytic product. In comparing the cost of sterilization by electrolytic hypochlorite with that of ozone it should be remembered that the figures for hypochlorite referred to sewage effluent as against Paris water for the ozone.

Drs. Kanthack and Rideal found that one gram of available chlorine in the form of electrolytic sodium hypochlorite would sterilize 1.21 cu. m of settling tank effluent or 1.5 cu. m of filtered effluent. Now, in any good electrolyzer 1 kw-hour (1 B.t.u. = Board of Trade unit) will give from 152 to 200 grams of available chlorine. Taking the lower figure, this is equivalent to 24.95 B.t.u. per 1,000,000 gal.; while 133 B.t.u. are consumed in the ozone process for the same quantity of liquid treated. Nothing remains to be said for the ozone as compared with electrolytic hypochlorite except the cost of salt for the latter (1 penny for 10 lb. in London); but in both cases capital outlay, maintenance and depreciation have been taken into account.

Mr. W. Pollard Digby, who was engaged in the Guildford and Maidenhead experiments, had told him that his records show that in 1896 to 1898 he was producing electrolytic hypochlorite at an inclusive cost of 15d. per kilogram of available chlorine, making the cost of complete sterilization 1.24d per 100 cu. m. But modern plant reduces the cost to 10d. per kilogram; and with salt at 1d. per 10 lb. and electrical energy at 1d. per B.t.u., the cost of sterilizing sewage effluent would now be 0.83d. per 100 cu. m, or 0.038d. per 1000 gal. Taking the figure of 0.055 franc, given in the author's paper, for 1 B.t.u., the total cost would be 0.027d. for electrolytic hypochlorite against 0.333d. for ozone.

Speaking as a water-works engineer, he attributed the slowness with which sterilizing processes are being taken up in England to the dislike entertained by the old type of engineer to any patented process. As the author had pointed out, assuming sterilizing to be practicable in England as in Paris, an enormous saving might be effected in London water supply by reason of storage reservoirs not being required and the higher rate of filtration permissible.

Dr. Rideal, in replying, said the process could be looked after by laborers and admitted of testing being carried out easily. He would try to obtain further information as to cost. London water would probably require considerably less ozone than Paris water, owing to the smaller amount of organic matter. It might be possible to replace filtration by the ozone process.

The figures of French chemists cannot be compared with English results on account of the different methods used. He agreed with Mr. Shenton as to the lower cost of hypochlorite.

With regard to the chairman's observations as to expenditure, what would be the cost of the new storage reservoirs? Would it be less than £90,000 per annum, including interest on capital charges?

Professor Whitaker remarked that London was not to be compared with any other place either in this world—or the next.

The Standardization of Firebrick and Refractory Materials.

On Jan. 4 a meeting of representatives of several technical institutions constituting the "Committee for Standardization of Refractory Materials" was held at Stoke-on-Trent under the presidency of Mr. J. E. Stead, F.R.S. The adoption was recommended of a preliminary scheme to include (a) the classification of refractory materials; (b) the drawing up of standard specifications for raw materials and finished products; (c) the consideration of making arrangements for uniformity in certain stock or standard sizes, and (d) the standardization of testing and analytical methods.

The representatives of the various societies agreed to acquire all possible information in connection with their especial requirements and particulars of furnace temperatures and working conditions. Each section will work independently, and will report to the next meeting of the general committee, which will finally publish a general report, to be revised periodically and kept up to date. The groups of sections are entitled, respectively: Industrial Sections, Ceramic Society Section, and Manufacturers' Sections. The first includes the chemical and electrical, the metallurgical, the gas engineers', the pottery, and the glass sections. These will deal with (1) materials at present in use, any general information as to analyses, etc.; (2) conditions of use, nature of furnace operations, temperature, and whether the temperature is continuous or intermittent; (3) criticism of materials at present in use; (4) suggestions as to improvement, both in material and in sizes and pattern available.

The Ceramic Section will give attention to (1) definition of refractoriness; (2) grades of materials, based on (a) refractoriness; (b) class of material—aluminous, as clay and bauxite; silicons, as ganister and silica; special, as magnesite, etc.; (3) examination of raw materials; general, as to presence of calcium carbonate, coal, pyrites, etc.; chemical analysis, standard methods; refractoriness, methods of determining; mechanical analysis, methods, etc.; behavior at various temperatures, shrinkage, porosity, plasticity.

The manufacturers will formulate suggestions as to the elimination of odd and little used sizes and shapes; standard sizes and shapes; deviation from specified dimensions in special sizes; the grading of clays, as proposed by the English Ceramic Society, and general suggestions.

London, January, 1909.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Titanium-Silicon Alloy.—Mr. Fred M. Becket, chief metallurgist of the Electro Metallurgical Co., notes the fact that the reduction of titanium ore or of a mixture of titanium and iron ores by means of carbon yields a product high in carbon. The proportion of carbon amounts in the case of titanium carbide to 20 per cent by weight. This is a serious disadvantage in the steel industry. Mr. Becket has found that if silicon is alloyed with the titanium it is possible to reduce the carbon to reasonable limits, say, below 10 per cent. A charge containing 38 per cent rutile, 22 ferrosilicon (50 per cent grade), 20 scrap iron, 20 carbon, yielded an alloy containing 44 per cent iron, 34 per cent titanium, 14 per cent silicon, 8 carbon and traces of aluminium and calcium. The higher the percentages of titanium in the alloy, the more silicon must be added in order to hold the content of carbon down. (910,894, Jan. 26.)

Furnace Design.—Mr. J. H. Reid patents details of polyphase furnace construction. The first claim refers to "the combination with a source of polyphase current of an electric furnace having a crucible formed therein by a plurality of converging electrodes having different phases of the polyphase current flowing through each and an electrode adapted to extend into the top of the charge supported on said electrodes and being connected to the neutral point of the polyphase system." (910,582, Jan. 26.)

The furnace is intended as a combined arc and resistance furnace, since besides "the arc-producing electrodes" it contains "a plurality of resistance elements, similar in form to the electrodes, all the resistance elements and the electrodes converging to a single point within the furnace, whereby a crucible will be formed on which the charge will be retained until it is reduced and brought to molten state, when the molten elements may drop between the resistance elements and the electrodes." (910,581, Jan. 26.)

Electrolytic Processes.

Manufacture of Sodium Peroxide and Sodium Cyanide.—Two of the chief uses of metallic sodium (made electrolytically by the Castner process) are the manufacture of sodium peroxide and of sodium cyanide. Mr. C. F. Carrier, Jr., calls attention to the fact that the whole sodium recovered as peroxide or cyanide enters into the usual processes as metallic sodium; the reaction is in the fast case $Na + 2O = NaO_2$, and the reaction of a certain cyanide process now in use is given by two equations $NH_3 + Na = NaNH_2 + H$ and $NaNH_2 + C = NaCN + H_2$. To reduce the amount of metallic sodium used as starting material, Mr. Carrier uses "a fused bath containing sodium salts, which will be decomposed by sodium, or sodium alloy, in such a manner as to render the combined sodium of the bath available as a source of sodium atoms for the end product; and add sodium, or sodium alloy, to this fused bath." This general principle may be made clearer by application in the two cases above cited.

If sodium be added to a mixed fusion of sodium hydroxide and sodium nitrate in the proper proportions, namely, approximately two parts by weight of the latter to three parts of the former, there are numerous possible reactions, the final state of which may be expressed by the following reactions:

$$NaNO_3 + 3\,NaOH + 8\,Na = 6\,Na_2O + NH_3 \qquad (I)$$

$$6\,Na_2O + 3\,O_2 = 6\,Na_2O_2 \qquad (II)$$

$$NaNO_3 + 3\,NaOH + 2\,Na = 3\,Na_2O_2 + NH_3 \qquad (III)$$

Reactions I and III take place at the same time, the preponderance of either reaction depending upon the condition of the operation and the law of mass action. The actual amount of sodium peroxide produced will, therefore, lie between the results of reaction I + II and reaction III. This same principle may be applied to the production of sodium cyanide. If metallic sodium be added to a fused bath of NaOH in which carbon is suspended and NH_3 gas be bubbled through the melted mass at the same time the following reaction takes place

$$NaOH + Na + 2\,NH_3 + 3\,C = 2\,NaCN + CO + 7\,H.$$

Instead of employing pure metallic sodium Carrier finds it advantageous to use lead sodium alloy, as it may be produced easily by electrolysis of fused sodium chloride with a fused lead cathode (the old Acker process). But the simple addition of lead-sodium alloy in place of sodium to such a bath as specified above for making oxides of sodium is not practicable because lead would be oxidized as well as sodium and the sodium oxide would be contaminated with sodium plumbate. Likewise the alloy could not be used in the formation of sodium cyanide because the alloy produced in practice has not sufficient reducing power to give the desired result.

The author uses a double compartment cell, like that employed in the Ashcroft process, connection between the two compartments being made by fused lead. The "anode com-

partment contains fused sodium chloride so that sodium is deposited onto and alloyed with the fused lead cathode. The sodium lead alloy is anode in the "cathode compartment" filled with fused sodium hydroxide. By using an iron or nickel cathode in this compartment, sodium would enter into the fused bath from the fused lead alloy and metallic sodium would be deposited onto the cathode. That would be the Ashcroft process. The feature of Carrier's process is that if $NaNO_3$ is added, at intervals in amount proportional to the number of amperes used, the sodium of the lead-sodium alloy will be consumed as fast as liberated according to the following reaction:

$$xNaNO_3 + y\,NaOH + z\,Na = a\,Na_2O + b\,Na_2O_2 + c\,NH_3.$$

The relative values of the factors a, b, c and x, y, z, will depend upon the condition of the operation. This mixture of $Na_2O + Na_2O_2$ can be entirely converted into Na_2O_2 by solidifying, pulverizing and heating the powder to over 300° C. in air free from CO_2 and H_2O. The lead-sodium alloy, which has been partly depleted of its sodium, is continuously returned to the first compartment.

The production of cyanide of sodium is conducted in the same way, except that a different electrolyte must be used in the second compartment. In this case the fused NaOH holds carbon in suspension. The bath is electrolyzed as before and ammonia gas is bubbled through the electrolyte in place of the $NaNO_3$ used when sodium oxide was desired. The value of the process, if commercially successful, lies in the production of more of the final product than could be produced from the actual quantity of the metal entering into the reaction as metal or alloy only. (910,498, Jan. 26, 1909.)

Caustic Soda and Chlorine for Treatment of Fibre.—By electrolysis of brine, caustic soda and chlorine are produced, both of which are used for the treatment of cellulose fiber, the caustic for separating the fiber from the wood and the chlorine for bleaching. The chlorine gas must be combined with lime to form "bleach" before it is applied to the fiber. The caustic soda effluent from diaphragm cells generally consists of about equal parts of caustic soda and undecomposed salt. The sodium chloride must be separated from the caustic before the latter is applied to the fiber. Messrs W. V. Wentworth and A. B. Larchar, of the Penobscot Chemical Fiber Co., proceed as follows (Mr. Larcher being the inventor of a diaphragm process which has been described before in this journal): The mixture of caustic soda and sodium chloride is supplied to an evaporator, where it is concentrated, part of the salt crystallizing. The salt crystals with entrained caustic soda are supplied into a vacuum receiver, while in a viscous condition, and are then blown by compressed air into a filter tank, where they are allowed to cool to deposit more salt crystals. Then a valve is opened and the concentrated caustic soda is allowed to filter through simply by gravity and is collected and ready to be applied to the fiber. After several washing operations, the salt crystals are dissolved in hot water and returned with fresh salt to the electrolyzing tanks. The chlorine is passed through a series of absorption towers, where it meets descending streams of milk of lime and forms chloride of lime. The whole apparatus is so arranged that the electrolyzing cells, the concentrator, and the absorption towers are in continuous operation and yield a continuous supply of both bleach and caustic soda. (Apparatus patent 912,339, Feb. 16; process patent 912,340, Feb. 16.)

Electrolytic Refining of Precious Metals.—An apparatus, specially adapted for the refining of precious metals, is patented by Mr. Henri Lacroix. It is described in detail and illustrated in an article of the inventor elsewhere in our present issue. (912,859, Feb. 16.)

White Lead.—Mr. E. D. Chaplin makes white lead by the following electrolytic process, using a three-compartment cell formed by two porous diaphragms. Sodium nitrate is introduced into the middle compartment; one outer compartment contains a lead anode, the other a copper cathode. Lead nitrate is formed in the anode compartment and sodium hydroxide in the cathode compartment. "For the purpose of preventing the anolyte from becoming unduly alkaline, because of the liberation of nitrous oxide during the decomposition of the nitric acid in the anode compartment, or from any other cause, and for preventing the resulting formation of insoluble lead salts," nitric acid is added to the anode compartment. (This is made electrolytically in a separate cell from sodium nitrate with a carbon anode.) The lead nitrate and the sodium hydroxide are withdrawn into separate vats. The hydroxide is changed into sodium carbonate by carbon dioxide. The lead nitrate and sodium carbonate are then mixed in a separate precipitating tank; lead carbonate settles on a filter, while the filtrate, which is substantially the original electrolyte, is pumped back into the supply tank. (906,102, Dec. 8, 1908.)

A second patent of the same inventor relates to the manufacture of white lead (or lead chromate, etc.) from crude lead bullion or lead ore, carrying silver, copper, etc. The crude bullion is cast into anode plates. The electrolyzing cell is the same as above. But the electrolyte is a mixture of sodium nitrate and sodium chloride or sodium chlorate (the latter two being added to prevent the formation of insoluble basic salts of lead in the electrolyzer). Sodium hydroxide is again formed in the cathode compartment, while a mixed solution of soluble acid salts of lead, silver, copper, etc., is formed in the anode compartment. This is withdrawn; the silver is precipitated by means of copper in form of copper scrap or ingots, etc.; the solution is again withdrawn and the copper is precipitated by means of lead. The further treatment is like above. (906,103, Dec. 8, 1908.)

The apparatus for carrying out these processes is patented in patent 906,104, Dec. 8, 1908.

Electrolytic Detinning of Tin Scrap.—Mr. Meredith Leitch, who has paid considerable attention to electrolytic detinning during the past few years, has taken out two more patents relating to this subject. The first refers to the method of heating and circulating the caustic soda solution. The solution is withdrawn by means of a pump from the detinning bath at a point near the bottom, where it is coolest, is forced through a boiler, where it is heated, and returned to the detinning bath at a point near the top, but below the surface of the electrolyte. The advantage over an overflow arrangement is that with this method of circulation the caustic soda does not come in contact with air, which would result in formation of carbonate. (907,061, Dec. 15, 1908.)

A second patent of Mr. Leitch describes a modification of his apparatus illustrated in our Vol. V, p. 103. There is again a U-shaped basket with perforated walls, having in its interior a conveyor chain carrying tin scrap through the cell. On both sides of the basket are cathode plates. The whole is contained in a tank filled with electrolyte. According to the present invention, the tank is lowered at certain intervals, the electrolyte run off, the tin powder removed from the cathode plates by scrapers and the apparatus is cleaned. (906,726, Dec. 15, 1908.)

Electroplating.—For plating a large quantity of small articles, revolving drums, containing these articles, are widely used, as a good circulation of the plating solution is automatically obtained and the articles tumble continually above each other and present in succession all their surfaces to the plating solution so as to get a good all-around deposit. Much of the success of such apparatus depends, of course, on the mechanical construction. Mr. Clarence J. Backus has patented the following design (assigned to Zucker & Levett & Loeb Co., of New York): A rectangular wooden tank contains the electrolyte and within it is placed the revolving cylinder of wood. This has solid circular end plates, the peripheries of which are connected by a series of longitudinal wooden strips. The sides of these strips, of course, taper toward the axis of the drum so as to fit together, and they are provided with a series of grooves which are staggered on the adjacent strips and form

openings through which the plating solution enters into the interior of the drum while it revolves. A portion of the wall of the drum is removable for the purpose of inserting the articles to be plated or for withdrawing them. The cathodes which make contact with the articles to be plated are knobs or balls suspended from the axle of the cylinder so as to be always slightly above the lower surface of the cylinder and to make continually contact with the articles to be plated. The anodes are curved bars surrounding the cylinder from the outside. (908,439, Jan. 5, 1909.)

A patent of Mr. John T. Daniels (assigned to the Hanson & Van Winkle Co., of Newark, N. J.) relates to the material from which the sides or walls of revolving electroplating drums are made. The drum is made of a wooden frame to which are secured sheets or panes of celluloid or xylonite, or "of other mixture of nitro-cellulose with other material, resulting in a non-fibrous, homogeneous substance capable of being readily drilled or punched, free from sulphur or other vulcanizing ingredients, and insoluble in, and unaffected by electrolytes used for electroplating." The sheets are provided with a very large number of minute perforations. Celluloid, etc., is stated to have very decided advantages for this purpose. (911,578, Feb. 9. 1909.)

Miscellaneous.—An electrolytic sterilizer for liquid food products is patented by M. R. Frei (907,140, Dec. 22, 1908); an electrolytic apparatus for the purification and sterilization of water, using a series of different metals (iron, zinc, aluminium, manganese dioxide, copper) as electrodes is patented by D. L. V. Browne (910,495, Jan. 26, 1909); a process of separating cream from milk by "passing a series of electric impulses through the milk," by R. W. Padden (907,637, Dec. 22, 1908)

Treatment of Gases.

Chlorine.—Mr. E. C. Paramore claims to be able to purify chlorine gas and relieve it of its objectionable odor, without detracting from its bleaching quantities, by the following process: The raw chlorine gas is washed with acid to remove moisture and impurities, then cooled in a special refrigerating apparatus, then heated to a high temperature to prepare it for electrification, then passed into a "compound magnetic dielectric device," having "a glass chamber through the walls of which both an electrostatic and magnetic induction influence are caused to pass in such a manner as to effect an increased chemical activity of the gas and deodorization thereof, presumable by its full or partial ionization." The purified gas is finally passed through a second refrigerating condenser of lower temperature than the first for the purpose of liquefying it. (908,126, Dec. 29, 1908.)

SYNOPSIS OF PERIODICAL LITERATURE.

Iron and Steel.

Power Consumed in Rolling.—Director H. Ortmann, in Völklingen, delivered a report of the work of the German commission upon this subject, in a lecture before the Verein Deutscher Eisenhüttenleute, on Dec. 6. The report is abstrated in twenty-eight large pages in *Stahl und Eisen* for Jan. 6, and is of importance to every metallurgist concerned with the rolling of metals because the methods if investigation and the general formulæ found are applicable to rolling in general. The full report will have to appear as a separate publication. The machinery used was equipped with motor drive and with all necessary electrical instruments for determining the power exerted and consumed. The temperature of the steel at each pass was taken by a Wanner pyrometer. The results are expressed as the volume of material expelled from the original length, per unit of energy employed. That is, letting S be the original section, S' the reduced section, L the original length, and E the energy consumed in the operation, then

$$\frac{(S - S')\,L}{E}$$

is used as the expression for the extended volume per unit of energy employed. Diagrams are given using this quantity as ordinate and temperature as abscissæ. Chemical analyses, mechanical properties and shapes of the section tested are given. Using lengths in millimeters and energy consumed in meter-kilograms, the tests showed, in rolling different forms, at different temperatures, the following general values for the member of cubic millimeters of steel displaced per kilogrammeter of energy consumed, at different temperatures:

	1300° C.	1200° C.	1000° C.	900° C.
Square ingots to Flat rectangles	100	45	20	18
Round	80	50	..	.
T-girder	85	60	20	10
Rail	..	70	20	

The thorough study of the article is recommended to all interested in the scientific study of rolling metals.

Blast-Furnace Slags.—The November 22 issue of *Metallurgie* contains a long article on the constitution of blast-furnace slags by M. Theusner, of the Berlin Technical School. We are obliged to omit the reproduction of very elaborate lithographed chart. The paper opens with a discussion of previous work along this line, some of the investigations on the constitution of Portland cement also being noted. For the study proper four blast-furnace slags of the following localities and compositions were taken:

	SiO_2	Al_2O_3	CaO	MgO	FeO	MnO	S	P_2O_5
Bochum:								
Slowly cooled	29.47	13.96	45.65	6.2	0.77	0.48	2.89	...
Chilled	29.68	13.84	45.48	6.29	0.68	0.54	2.72	.
Kneuttingen:								
Slowly cooled	31.20	17.36	44.00	3.74	0.58	1.32	1.42	..
Chilled	31.30	17.65	43.70	3.60	0.49	1.36	1.38	
Neunkirchen:								
Slowly cooled	30.75	18.10	42.88	3.78	1.20	1.64	1.82	0.02
Chilled	30.83	18.18	42.73	3.74	1.18	1.58	1.63	0.02
Kratzwieck:								
Slowly cooled	25.63	14.90	51.21	3.64	0.60	0.20	4.13	0.02
Chilled	25.71	15.02	51.03	3.53	0.57	0.25	4.00	0.02

The chilled slag was made by granulating in water Three solutions were used in the investigation: (1) a 2 per cent solution of citric acid; (2) a solution of ammonium citrate made by adding to 10 liters of water 1500 grams of citric acid and 3594 cc of ammonia, specific gravity, 0.967; (3) a saturated solution of ammonium chloride; 5 grams of finely ground slag were used in each test. The chilled slag settled in the solution more rapidly than the slowly cooled, and was in general more quickly attacked than the slowly-cooled slag. The more lime in the slags the easier the attack. Alumina plays the part of a neutral material. Complete tables are given of the amount dissolved from the various slags by the three solutions in two, five and eight hours, the composition of the residue and the composition of the dissolved portion. In general, the more basic the slag the greater the decomposition. In the basic slags a large portion of the lime goes into solution, the proportion of silica to alumina remaining quite constant in the residue. In the less basic slag a proportionately larger amount of lime remained in the residue. The change in the various slags is well shown in a tri-axial diagram. Microscopic examination of the slags showed in the Neuenkirchen slag rectangular crystalline aggregates which were determined to be mellilite. The Kneuttingen slag showed the same, but not so prominently A slag of the composition of mellilite was made up and subjected to the action of the three solutions used in the original investigation with an identical result. Mixtures were made up consisting of all possible combinations of 60, 10 and 30 parts of SiO_2, Al_2O_3 and CaO and treated with the three solutions and examined microscopically, the results given in photographs and tables, but no conclusions drawn therefrom.

Cupol Practice.—Th. Ehrhardt, of Halensee, Berlin, describes in *Stahl und Eisen* of Jan. 13 some recent improvements in cupola practice The principal are the automatic charging apparatus, spark catchers outside the roof and fore-hearths

[illegible] overflow of slag, and intermittent [illegible]

Cupola Economy.—Dr C. Geiger, of Dusseldorf, has made [illegible] cupola experiments using

Dry coke with 0.5 to 0.8 per cent of water.
Moist coke with 5 to 8 per cent of water.
Wet coke with 10 to 18 per cent of water.

The cupola had a fore-hearth 0.9 m in diameter by 1.05 m deep, and melted 3.5 tons per hour. Careful analyses were made of the cupola gases and all weights of fuel and iron recorded. The results showed the water to keep the top of the cupola cooler, to decrease the percentage of CO in the gases and increase that of CO^2, while in consequence the total fuel used (dry weight) was diminished. The figures are as follows:

	Water	CO^2.	CO.	Carbon used per 100 kg. iron.
Dry coke	0.5	13.3	10.7	6.89
Moist coke	0.5	10.0	7.2	6.58
Wet coke	10.0	17.7	5.0	5.95
Very wet coke	18.0	17.3	6.0	5.59

The reason for the economy is hinted at in the article, but not very clearly set forth. It is undoubtedly due to the fact that when a kilogram of dry coke goes into the cupola it soon becomes heated and commences to reduce CO^2 to CO. If, however, it carries with it 0.22 kg of water (as in the very wet coke), this absorbs, in being evaporated, at least 150 calories, thus taking heat which the carbon would otherwise, in great part, absorb. Such 150 calories would raise the kilogram of coke 300° C. or 400° C. The coke is thus kept cool for a considerable time and to a considerable depth in the cupola, the time during which it can reduce CO^2 to CO is correspondingly shortened, and the resulting increase of CO^2 in the gases is explained. This, of course, means a corresponding better utilization of the fuel.

Low-Grade Iron Ores.—An entirely new scheme for the treatment of low-grade iron ores appeared recently in *Iron Trade Review*. It is called the "step process," and consists in passing the finely ground ore through a revolving cylindrical furnace at the same time reducing the oxide of iron to metal by means of a current of gas rich in hydrocarbons. All the gangue of the ore remains unreduced and intimately mixed with the metal. It is removed later by a squeezer or balling mill. The product is to be used in place of steel scrap in open-hearth practice. The process can be applied to very low-grade ores at a cost of less than $1.50 per ton of material treated.

Melting Point of Iron.—It comes somewhat as a surprise to most of us to find that we have been using a figure some 100 deg. too high for the melting point of pure iron, but such seems to be the case from the figures given by H. Carpenter in *Metallurgie*, Nov. 22. He gives as the melting point of pure iron 1505° as measured by Le Chatelier pyrometer and 1491° to 1519° for optical scale. The freezing point is independent of the gas in contact with the metal, a fact difficult to explain when we know that oxide of iron is quite readily dissolved by the molten iron.

Tin.

The History of Tinning.—Otto Vogel, of Dusseldorf, in a lecture before the "Deutscher Giessereifachleute," Dec. 5 (reprinted in *Stahl und Eisen*, Jan. 13), relates some interesting history. Although the invention of tinning is generally credited to the Gauls, on the authority of Pliny, yet the author has unearthed a paragraph of Theophrastus, who lived and wrote 300 B. C., which says: "It is related of the Athenians that they dip red-hot clean iron into earthen pots containing tin. This operation does not alter the weight, but is done to avoid the taste which the iron articles otherwise impart to the food." Pliny said, several hundred years later: "The tinning of copper cooking utensils gives the food a better taste and protects from the poisonous verdigris, and without making the vessels heavier." This statement about the weight not being changed apparently passed current for centuries, until Beckmann, in 1797, weighed carefully a copper vessel before and after tinning, and found that it had really gained 2 per cent in weight. The history of the legislation against the use of lead in the tin, in lining cooking utensils, beginning at Berlin, in 1768, is curious and interestng.

Fuels.

Moisture in Coke.—Experiments are described in *Stahl und Eisen* of Jan. 6, on the amount of water which red-hot coke can absorb when quenched in cold water, which led to "the surprising result" that three to four times as much water is thus taken up as is absorbed by the same coke when dipped cold into hot water. It appears to us that a little reflection will remove the cause of the surprise. Coke possesses pores which remain filled with air even when dipped into water. For a rise of temperature the gases contained in said pores diminish in density, such that at a bright red-heat (800° C.) the real quantity of gas present in the pores is only one-quarter what it would be if the coke were cold. Quenching the bright red-hot coke, therefore, imprisons in the pores only one-fourth the quantity of air or gas, and allows, therefore, three or four times as much water to get into the pores as when the coke is first cooled and then dipped into warm water.

Miscellaneous.

Manganese Bronze.—J. L. Jones, in *Metal Industry* for January presents a time criticism of the government specifications for manganese bronze. The figures given for elongation and for contraction of area should be made very much more nearly equal. The specifying of an elastic limit without the details as to how it is to be determined is quite meaningless when the effect of the method of test on the figures obtained is considered. The author also criticizes the clause calling for a foundry test on the part of the government, claiming that the ignorance of the government molder as to the handling of the particular alloy submitted might lead to the condemning of an otherwise satisfactory alloy.

Antimony.—With the increase in the demand for antimony in the alloy and pigment industries there has appeared several articles on the metallurgy and treatment of this metal. The most recent one appeared in *Revue de Chimie Industrielle* for October by the French metallurgist, Pautrat. The older method of liquating the stibnite ores and precipitating the liquated sulphide by iron is fast disappearing. The more modern method is to charge the ore with fuel in a furnace similar to a lime kiln and urge the fire with a large excess of air. The antimony sulphide liquates out, is oxidized and the oxide condensed in suitable chambers and flues in combination with the furnace. The purity of the condensed oxide varies greatly in the different chambers of the condensers, though it is not uncommon to obtain a product carrying 98 to 99 per cent oxide. Arsenic oxide is the greatest impurity. For reduction to metal this oxide is briquetted and charged into a reverberatory furnace with coke and carbonate of soda in the proportions of 100 oxide, 70 soda and 80 carbon. A scheme for analysis of arsenic and antimony oxides concludes the paper.

Silicon as Reducing Agent.—Paul Askenasy communicates to *Zeit. f. Elektrochemie*, Dec. 11, some interesting facts regarding the use of silicon for reduction and fusion of various materials. When barium peroxide and fine silicon powder are mixed together and the mass ignited, the reaction is usually so violent that the mass is blown out of the containing crucible. The author has found that by using a coarser barium peroxide the reaction can be completely controlled. A barium silicide was made by mixing 50 parts of barium peroxide and 13 parts of powdered 90 per cent silicon and igniting. The silicide contained about 30 per cent barium. It is quite brittle and decomposes water with evolution of hydrogen, and hydrochloric acid evolves silicon hydride from it. On mixing 2 kg of barium peroxide, 80 grams of sodium peroxide and 1.4 kg

of iron filings and igniting, the iron was melted and run out the bottom of the crucible similar to thermit iron. The silicon did not alloy with the iron and the reaction is not so violent with dry materials as to expel the mass from the crucible. Copper can be fused and raised to the same high temperature in the same manner. It is possible also to reduce several metallic oxides. Very finely pulverized ferrosilicon can be used instead of the silicon for fusing the iron, no silicon entering the latter metal. By mixing titanic acid and silicon a silicide of titanium, Ti_2Si_3, was obtained, and on using this mixture with the peroxides iron was melted which contained considerable titanium and was very hard.

Aluminium Carbide.—Askenasy, in *Zeit. f. Elektrochemie*, Dec. 11, gives some new information of the formation and decomposition of aluminium carbide. Briquettes were made of alumina and wood charcoal in the proportions $2\,Al_2O_3 + 9\,C = 6\,CO + Al_4C_3$. They were heated in an electric arc furnace and after removal were found to have been transformed into scaly crystals of black color. On lying in the air for several days the briquettes fell apart, and in the interior were found yellow carbide crystals. On separating these crystals and heating them in a porcelain crucible it was noticed that when the temperature was raised but slightly above the melting point of aluminium this metal sweated out. In general, when the mixture, after heating in the electric furnace, was cooled quickly carbide only was obtained, but when the mass was cooled slowly metal always oozed out of the pieces.

RECENT METALLURGICAL PATENTS.

Copper.

Pyritic Smelting.—In attempting to smelt by pyritic methods certain classes of copper or copper-nickel ores which are otherwise suitable for the purpose, difficulty is experienced owing to the refractory nature of certain constituents of the ore, among the most important of which are certain coarsely crystalline feldspars. Such material is in a high degree chemically inert and attains no more than a plastic condition at the highest temperature ordinarily attainable in a pyritic furnace, in which condition it is incapable of readily entering upon the chemical changes necessary for its conversion into slag, but, on the contrary, it forms accretions which in a short time choke the furnace. Mr. James Taylor Carrick, of Johannesburg, proposes to overcome this difficulty by producing in the furnace, at the base of the "focus" (the region of active slag formation), a restricted zone of higher temperature than the rest of the furnace. In coming into contact with it, the "infusible" ore constituent becomes liquefied, when it is at once acted upon by the other parts of the charge and thereby reduced to readily fusible slag. Such zone is advisedly as narrow as possible consistently with the total liquefaction of the ore, since any considerable increase in the total heat of the furnace is not aimed at, nor would it be desirable. To produce the specially hot zone a special series of twyers is provided immediately below the level of the air blasts, and through those twyers gaseous fuel with air is introduced, producing special flame blasts just sufficiently below the regular air blasts for the combustion of the former to be completed before they mingle with the air blasts. (912,540, Feb. 16.)

Iron.

Petroleum for Iron Reduction.—Mr. Edward D. Kendall proposes to reduce iron oxide ores by means of petroleum or products from petroleum. The ore is first crushed or pulverized, a hard red hematite should preferably be pulverized to pass through a sieve having 40 meshes to the linear inch. This comminuted ore is to be thoroughly mixed with granulated or pulverized lime or limestone, broken or crushed lime or limestone may be added. With this mixture is to be incorporated heavy petroleum, practically non-volatile at the ordinary temperatures, or petroleum residues, liquid, semi-solid or solid, which remain after distilling off the lighter hydrocarbons from the natural petroleum. Granulated or pulverized hematites alone cannot carry in the interstices enough petroleum or petroleum-product (liquid or melted solid) to effect complete reduction of the ore and, therefore, must be associated with the lime or limestone; that is to say, with the slag forming body or bodies, in order that the mass shall have a sufficient capacity of absorption. The temperature required for reduction is below red heat, so that reduction may be accomplished in suitable well known forms of iron retorts, the melting of the slag-forming bodies and fusion of the reduced iron to be effected afterward in a suitable furnace. (12,918, Feb. 9, 1909.)

Alloys.

Bearing Metal.—A suitable alloy for journal bearing and shaft bearings may be obtained, according to W. G. Black, by the following composition: Copper, 50 to 60 per cent; iron, 40 to 50 per cent; nickel, 4 to 6 per cent; lead, 6 to 15 per cent; aluminium, one-quarter of 1 per cent to one-half of 1 per cent. The main object of incorporating lead into the alloy is to impart a certain degree of softness to the alloy, the quantity of lead that is introduced varying according to the use for which the alloy is intended. The nickel in the alloy is greasy and thus acts as a lubricant. (912,645, Feb. 16, 1909.)

Thorium.

Reduction of Thorite.—To recover thorium from ores Mr. Robert McKnight mixes the comminuted ore with sodium chloride much in excess of the amount required to furnish chlorine for the chloridizable constituents of the ore. The mixture is heated in a revolving cylinder to a temperature which need not exceed 700° C. By this treatment the thorium in the ore is converted into a volatile and soluble chloride or double chloride of sodium and thorium. What is volatilized is condensed in a suitable condenser, and the residue, preferably while hot from the furnace, is allowed to fall into water, and thus by the sudden change of the temperature is quickly disintegrated and crumbled and the portion of the thorium which has not volatilized is obtainable in solution, from which its oxide or the metal itself can be obtained in any suitable manner. A limited amount of water is preferable to obtain a supersaturated solution of the thorium, which on standing is precipitated, leaving the more soluble alkaline chloride in solution, from which it can be recovered by spontaneous evaporation or otherwise and used in the treatment of the new ore. The principal reaction in the reduction of thorite ore, according to this process, is given by the following equation:

$$ThSiO_4 + X\,NaCl + O \text{ (the atmosphere)} = Na_2SiO_3 + ThCl_4 + 2\,Na_2O + (X-6)\,NaCl + Cl_2.$$

(912,485, Feb. 16.)

Titanium.

Reduction of Refractory Oxides.—In the well-known aluminothermic reaction of Goldschmidt aluminium is used as reducing agent for refractory oxides. K. A. Kühne has formerly proposed to use a mixture of aluminium and chlorates or perchlorates instead of pure aluminium, and he now suggests to substitute peroxides for the chlorates or perchlorates. The use of barium peroxide or sodium peroxide is specially referred to. The object of adding this peroxide is to accomplish that "its oxygen may, by increasing the rate of oxidation, raise the temperature so high that even those oxides may be reduced that could not be reduced by the original Goldschmidt process." Care must be taken to produce a slag which is as thinly fluid as possible. For this purpose suitable additions of fluorspar, lime, etc., are to be made. For the reduction of titanium by this process the equation is as follows:

$$TiO_2 + Al_2 + BaO_2 = Ti + Al_2O_3 + BaO$$

Evidently more aluminium is used in this case than in the aluminothermic reaction, because the aluminium has to absorb the oxygen both from titanium and barium. (910,394, Jan. 19.)

The Use of Titanium in Steel for Rails, Car Wheels, Etc.

By Charles V. Slocum

I have read with much interest various articles which have appeared in this journal from time to time on the consumption and wear of steel rails, car wheels, etc., with recommendations of the use of the electric furnace for steel refining. In my opinion, a very important factor to be reckoned with in future in all these matters is usually being entirely overlooked. This is the use of titanium in steel.

With the aid of titanium it is possible to make better rails from Bessemer converter steel than is possible without its aid from open hearth steel. With the aid of titanium it is possible to eliminate blow holes. It is further possible to remove the brittleness and increase the durability of chilled-iron car wheels; further, to improve nickel steel, chrome and nickel steel, etc.

These are very strong statements, but they are made on the basis of the experience gained in fifteen months' trials in many mills by scientists and by plain mill men.

The element titanium is introduced into the steel in the form of the alloy ferrotitanium. This is made by the electric-furnace process of Mr. Auguste J. Rossi (which has repeatedly been described in this journal) at the works of the Titanium Alloy Manufacturing Co., at Niagara Falls. The sales offices of the company are at 5500 Irwin Avenue, Pittsburgh, Pa. This ferrotitanium is sold under the trade name "titanium alloy." It contains from 10 to 15 per cent titanium, 5 to 7 per cent carbon and less than 0.5 per cent other impurities. The balance, some 80 per cent, is iron.

Titanium for Bessemer Steel.

Ferrotitanium was used for the first time in a heat of Bessemer steel in this country at the works of the Maryland Steel Co. in November, 1907, under the personal supervision of Mr. Simon S. Martin. The steel made at this first trial showed so much improvement over ordinary Bessemer that a further shipment of titanium alloy was hurried forward and trials in several heats were made on Dec. 10, 1907.

These trials developed several remarkable features, probably the most important of which was the unprecedented increase in the quantity of slag removed from the steel. The treated metal invariably lay "dead" in the ingot molds. The steel was absolutely free from blow holes. The titanium-treated ingots were noticeably better than the untreated ones. An examination of the record from the pyrometer gage for the day's work showed an increase of not less than 15° C. in the heat of the treated metal at a given point in excess of that of the untreated metal at the same point, while passing through the rolls.

The titanium alloy was added in the ladle after the blow, and after the manganese, the former being simply shoveled in cold by a laborer while the steel was flowing into the ladle.

The Maryland Steel Co. has since the foregoing trials run many heats treated with titanium alloy, with unvarying success. Aluminium was not used, and should not be used in any case, or at any time with titanium alloy.

Experiments on the use of titanium for Bessemer steel have also been made at the Duquesne works of the Carnegie Steel Co., at the Cambria Steel Co.'s works and others.

Very exhaustive trials of titanium alloy have been made at the works of the Lackawanna Steel Co. during 1908, under the direction of an expert from one of the largest railroad lines in America. These tests were markedly successful and the railroad in question now endorses the merits of the alloy for the marked improvement which it gives to Bessemer rails.

Rails treated with titanium alloy and made by the Maryland Steel Co. have been in service for several months on Kesslers Curve on the Cumberland Division of the Baltimore & Ohio Railroad, where the traffic and the grade are both very heavy. Diagrams of these rails have been taken at intervals of two to three weeks, together with diagrams of the plain Bessemer rails put in at the same time and place. The greater durability of the titanium rail is so marked as to be fairly startling. The lower plain rails, although of best quality Bessemer, have flattened or "flowed" considerably, while at this writing the titanium rails have not "flowed" at all. The upper plain rails are cut down practically the full depth of the flange of the wheels, while the upper titanium rails are cut less than half as much.

Titanium for Open-Hearth Steel.

Titanium alloy has been used by many open-hearth steel works with unvarying improvement to the product. The general characteristics are freedom from blow holes, increase of elastic limit, increased reduction of area, etc.

The increase in quantity of slag removed or "lifted" by the alloy is almost as remarkable in open-hearth steel as in the Bessemer product.

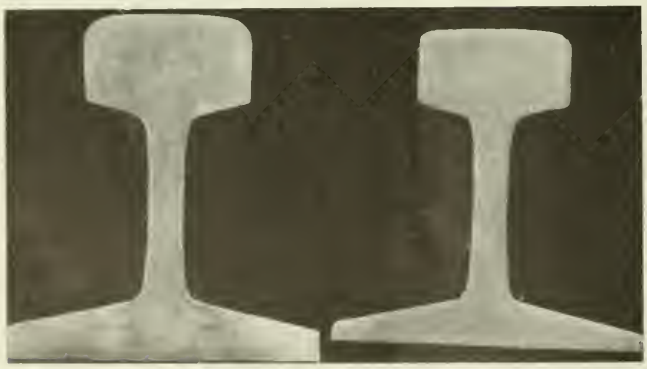
The titanium itself passes off with the slag which it removes, unless unusual quantities of the alloy be added, when the excess above the quantity necessary to remove the impurities remains in the steel.

Rolls made from open-hearth steel treated with titanium alloy are closer grained, absolutely free from blow holes or pin holes, are more durable than any other rolls, and are easily machined.

Open-hearth castings from metal treated with the alloy are more blue in color, are free from blow holes, are free from brittleness, are easily machined, and heat less under the tool, hence may be machined more rapidly than other steels of the same carbon content.

With respect to the removal of blow holes, the well-known high affinity of titanium for oxygen and nitrogen is, of course, of greatest importance. Any oxide of iron is perfectly removed by titanium.

The reaction due to the titanium addition is always accompanied by an evolution of heat which may result in an increase of temperature from 30° to 50° C. In an experiment of Messrs. FitzGerald and Bennie the rise in temperature, according to the Fery radiation pyrometer used, was 30° C., although the titanium caused the formation of slag which cut off the radiation somewhat from the pyrometer. They state that their tests indicate a distinct rise in temperature to be obtained "even



SECTION OF PLAIN BESSEMER STEEL RAIL. SECTION OF TITANIUM-TREATED BESSEMER RAIL.

Photographs made by Messrs. Garrett & Blair, of Philadelphia.

with so small an addition as 0.5 per cent of the 10 per cent titanium alloy."

In view of these facts the amount of ferrosilicon which would be used for the same purpose should be reduced, when ferrotitanium is employed. It is suggested that the silicon be reduced gradually from time to time until no further improvement is noted. If dirt specks are found in the surface or "skin" of the steel the ferromanganese should be slightly increased by adding, say, 10 lb. for each 100 lb. of Mn used, and the ferrosilicon should be cut out.

Ferrotitanium for Crucible Steel.

As said before, the use of titanium improves Bessemer steel so that it becomes better than present open-hearth steel. It brings open-hearth steel nearer to crucible steel quality. That with the aid of titanium it is possible to improve even electrically refined steel of crucible steel quality is indicated by the following tests quoted from Mr. F. A. J. FitzGerald's recent American Electrochemical Society paper (Electrochemical and Metallurgical Industry, December, 1908, page 494).

"The following tests were made from bars 1 in. sq. hammered from 6 x 6 bottom cast ingots. The elongation was determined in a length of 2 in.:

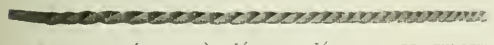
Heat No.	Tensile strength.	Elastic limit.	Elongation per cent.	Reduction per cent.
9	57,000	34,000	33	58
27	77,000	45,000	28	56

The steel of heat No. 27 was treated with 0.1 per cent of titanium."

The analyses given by Mr. FitzGerald are the following for the two heats mentioned above:

Heat No.	9	27
Carbon	0.10	0.22
Manganese	0.75	0.94
Phosphorus	0.015	0.033
Sulphur	0.070	0.056
Silicon	0.02	0.03

A bar of steel 4 ft. long, 1⅛ in. square made from this titanium steel (heat No. 27) was subjected to cold twisting



TITANIUM STEEL (HEAT 27), 1⅛ IN. X 1⅛ IN. X 4 FT., TWISTED COLD. SEVEN COMPLETE REVOLUTIONS.

test, seven complete turns or revolutions without a fracture. The accompanying illustration is reproduced from a photograph direct from the steel.

It has been found by experiment many times repeated that titanium alloy increases the strength of nickel and chrome nickel steel. It is a well-known fact that when nickel is added to steel an important percentage of oxide of nickel is formed. Titanium alloy used afterward thoroughly deoxidizes the metal. The alloy also "removes nitrogen in the proportion of about four parts titanium to one of nitrogen, a very important fact since neither chrome, nickel, molybdenum nor tungsten combines with nitrogen, so that none of these metals nor their ferros can be used for removing this gas to form with it a stable combination to pass into the slag." (A. J. Rossi.) Hence the following statement of Prof. Le Chatellier, of Paris, is very pertinent:

"The treatment of all steels with ferrotitanium for the purpose of the purification of the metal is strongly recommended. The presence of nitrogen to the extent of 0.02 to 0.045 or 0.035 in certain steels being enough to cause the metal to break asunder, destroying all elongation and reduction of area." (Congress of Metallurgists, Belgium, 1905.)

To sum up, the effect of titanium alloy in steel is to remove the oxides and nitrides to increase the fluidity and temperature of the metal and to increase the quantity of slag which it not only removes, but with which the titanium itself passes off.

The resulting product is stronger, more durable and more easily machined. The casting heats less under the tool and gives greater resistance to shock strain or wear. Titanium alloy has been used with success in gears, pinions, automobile cylinders, dies and die blocks, chilled rolls, car wheels, acid pots, etc.

Ferrotitanium for Chilled Castings.

Tests made by Prof. M. Hokanson at the Carnegie Technical Schools of Pittsburgh demonstrate that the crushing strength of chilled iron is increased nearly 100 per cent by the use of 1 per cent of titanium alloy. Prof. Bradley Stoughton, of Columbia University, recently placed this increase in strength for gray iron castings at 20 to 40 per cent. (Metallurgy of Iron and Steel, by Stoughton.)

Tests by the Brinell method show that chilled iron treated with titanium is harder than the untreated metal, although the chill is reduced by the alloy, and yet gray iron back of the chill is readily machined, such as hubs of car wheels, etc.

A number of tests of car wheels treated with titanium alloy are in progress on several different roads, both steam and electric.

In dies and die blocks the alloy gives tremendous resistance to shock and consequent large increase in life of such castings. The Midvale Steel Co. state they have adopted the alloy as standard in these castings.

A demonstration of the value of titanium alloy in iron was made at the car-wheel foundry of the Norfolk & Western Railway Company, at Roanoke, in August, 1908. One per cent of the titanium alloy was used in the charges and passed through the cupola without any other handling whatever.

Sixty wheels were poured from the metal treated with alloy in this manner, 15 test bars 2 in. x 2 in. x 24 in. were made during this period, then after all the treated metal had been poured off, 60 other wheels were poured and 15 more bars were taken from the plain metal.

After annealing, these bars were all broken on supports 21 1/3 in. apart. Two bars were imperfect and the comparative results of the other 26 are given below in deflection, the breaking strains not having been furnished:

Treated metal.	Plain metal
0.075	0.070
0.120	0.090
0.230	0.100
0.325	0.180
0.085	0.075
0.160	0.125
0.080	0.075
0.085	0.090
0.215	0.180
0.360	0.315
0.080	0.075
0.065	0.065
0.350	0.265
2.230	1.795

From the above it will be noted that this strong car-wheel iron treated with titanium alloy gave 24.4 per cent more deflection under stress than the plain metal, which is one of the best possible indications that the alloy removes brittleness and makes car-wheel iron more like wrought iron; an absolute preventive of chipped flanges, broken rims, shell outs, cracked plates, etc.

The sample wheels passed the drop and thermal tests with a wide margin of safety above both the M. C. B. and B. & O. specifications.

The alloy reduces the chill somewhat, but this is readily overcome by regulating the mixture correspondingly.

Titanium alloy may be used in iron in several different ways, viz.: in the furnace or cupola, in spout or ladle, and in the crucible.

By the first two methods it is merely necessary to add the

alloy the charge or charges without further attention.

When a reservoir ladle of iron is to be treated, the alloy is fed into the spout while filling first half or two-thirds of ladle. It is useless to add it later as it then unites with the slag and could have no effect on the iron. It should not be added in spout if the stream must pass through slag. The object of the alloy is to remove the slag still remaining in the iron. It is obvious that if the alloy unites with the surface slag it remains there and cannot later improve or even affect the iron.

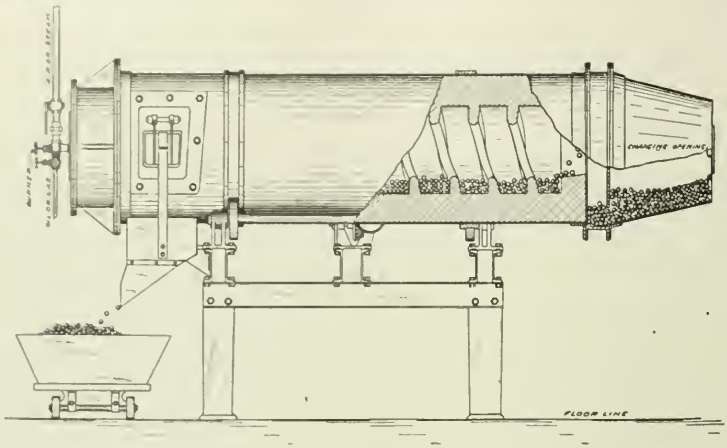


FIG. 1.—DIAGRAM OF THE HELICAL FURNACE.

In treating iron in smaller ladles for 100 to 500 pounds of molten metal, the alloy should be fed into the stream while filling the first half of the ladle, so that the alloy will receive much churning and swirling, the whole should be stirred vigorously for a moment with an iron rod (not with wood) and then pouring begins. The pouring need not be hurried, as the metal will be hotter and more fluid than usual in ordinary foundry practice.

The percentage of alloy to be used varies with the grade of iron to be treated and the results desired. Ordinarily 1 ½ per cent titanium is found to be a very good proportion, i. e., 1 lb. of the 10 per cent alloy to 100 lb. of iron.

In the crucible half of this percentage will have great effect.

As was mentioned on page 88 of the February issue of Electrochemical and Metallurgical Industry a special titanium alloy, "cupro-titanium," is made for use in the copper and brass industry. The use of this alloy ensures freedom from blow holes and permits the production of solid copper castings.

The Denver Fire Clay Co. have sent us their illustrated bulletins on the Case laboratory crusher, Case melting furnaces (for gasoline, gas or oil firing), muffle furnaces (for coal, wood, coke and oil firing), and metallurgical clay goods.

The Internally Fired Helical Furnace.

By C. M. Ripley.

Uniformity of heating of material in manufacture, if heating at all is necessary, is probably the most important operation to which the material is subjected, and has more influence to make or lose money for the manufacturer than any other. The good or ill effects of annealing or hardening extend to all future operations upon the metal and to the very life of the material itself.

Every practical manufacturer who handles material which requires annealing or hardening to fit it for use, knows that it is best and commands the highest price when it has been properly and uniformly heated. Yet he does not always realize how easily his furnace or his fuel may defeat his best efforts; or, on the other hand, how easily these two things, if right, may help him to complete success. I say help because while the furnace and fuel are fundamental, they are not all that is necessary. His employees must be carefully instructed and they must know that the heat treatment is right all the time.

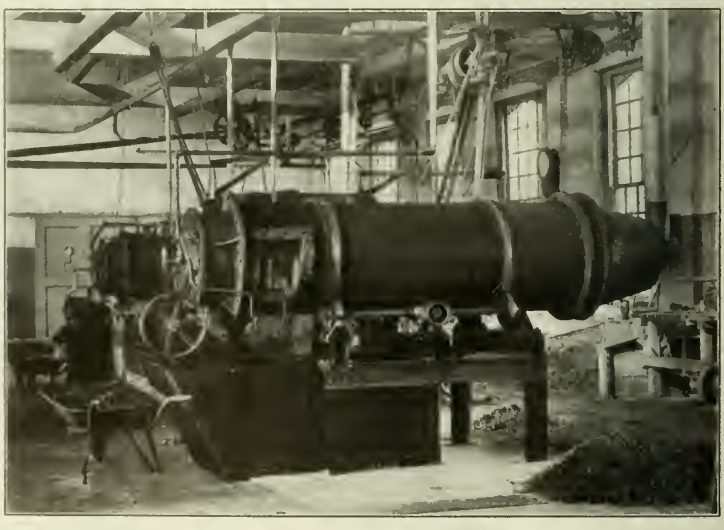


FIG. 2.—INTERNALLY FIRED HELICAL FURNACE.

Take Mr. Edison's cement furnaces for example—ten of them, 150 feet long, 9 feet internal diameter—at his cement works, New Village, N. J. Cement men said he could not successfully operate furnaces that long. Possibly he could not with their fuel and their methods. But he could and does with *his* method and *his* fuel—pulverized coal injected with a jet of compressed air at 80 lbs. pressure. The old furnaces were too short; so he made long ones. The coal was not suitable in its natural condition, so he pulverized it to suit himself. He permitted nothing to stand in his way. He

made the furnaces and fuel do what he wanted them to do—produce 8000 barrels of the first grade of Portland cement every day.

Much annealing and hardening is still done in old-style stationary furnaces, and owing to the size and shape of much of the material it must continue in that way, whatever the inconvenience and expense. Where size and shape have permitted some work has been and is being done in rotating cylinders heated from the exterior. Such cylinders are generally made of cast iron, but when heated externally the life of the iron is too short. Moreover, the heat is not utilized as economically as when directly applied by internal firing. Tumbling barrel furnaces and bucket and chain conveyor furnaces have been used for certain low-temperature work, each kind having its limits as to durability and efficiency.

In this country alone there are thousands and millions of small equal size bits of valuable material in brass, copper, steel, aluminium, gold, silver, and other metal, which must be annealed or hardened every day, such as cartridge shells, ferrules, eyelets, buttons, caps, cups, coin blanks, steel balls, saw teeth, tacks, screws, rivets, rings, springs, nuts, punchings, etc., and it was only natural that the internally-fired helical furnace here described and illustrated should have been designed to heat these pieces in wholesale fashion.

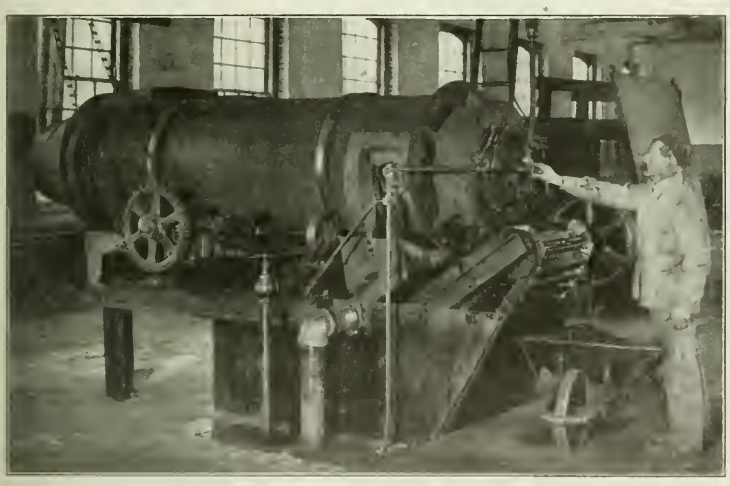


FIG. 3.—CHARGING OF THE ANNEALING FURNACE.

The furnace shown in the adjoining illustrations is formed of a steel cylinder, with a smooth fire-tile lining of helical form and is rotated upon rollers supported by a suitable iron frame. The power may be furnished from a line shaft or from a motor suitably controlled. Ordinarily the speed is from 1 to 3 revolutions per minute and the time of travel through the furnace from 3 to 10 minutes. Either oil or gas may be used as fuel, and it is injected directly into the chamber in the opposite direction to that of the travel of the material.

Combustion is complete, and the spent gases find vent where the material enters—giving up their heat to the incoming material as they pass, in the spirit of true economy. For not only is the heat thus saved, but the material is thereby heated up in that gradual manner which is best for it. The material is charged into the feed-drum in bulk and is then wormed through the furnace at a perfectly uniform and positive speed.

Starting cold the material winds its way through the convolutions of the furnace for a distance of about 47 feet, ever tumbling over itself, ever on a new hot surface, ever in the direct heat, yet only reaching its ultimate heat at the very point of discharge, where a pyrometer is so located as to show exactly what that ultimate heat is. Such heating is the exactly correct method, especially for hardening steel which should enter the bath at its rising hardening temperature. This action is important, also, in preventing or reducing oxidation.

Each piece is exactly right and the day's output is all the same. For example, a lot of 15,732 pieces of steel was run through one of the furnaces here shown and hardened in oil and each piece was then carefully tested. Only two were found imperfect, and they from flaws in the steel itself, not from the heat. The manufacturer stated that such runs were the rule, not the exception. Experience seems to prove that protection from oxidation and saving of time are both effected when the material is heated up gradually, never overheated and discharged the moment it has reached its ultimate temperature.

When the furnace was used for hardening a quenching tank with a conveyor was provided below the discharge spout so that the material after immersion was automatically removed from the bath quite clean and delivered into a truck or wheelbarrow. Provision was made so that two kinds of material could not become mixed; nor could any lodge in any part of the furnace or bath. By the simple removal of two bolts the conveyor could be easily removed from the bath, giving free access to every part thereof for cleaning or other purposes.

The furnace requires no chimney. A hood to carry off fumes from the oil bath or from machine oil on the material is sometimes desirable.

Either air or dry steam may be used to inject the oil or gas fuel. Coal or coke fuel cannot be used.

One of the chief features of the internally-fired helical furnace is its durability. Practically all the iron work is out of range of the fire, and all the parts are simple and strong.

The furnace is manufactured by W. S. Rockwell Company, 50 Church street, New York.

Silicon-Calcium-Aluminium Alloy.

A silicon-calcium-aluminium alloy is being introduced in this country by Messrs. C. W. Leavitt & Co., of New York City, the analysis being approximately silicon 47 to 57 per cent, calcium 15 to 25 per cent, aluminium, 2½ to 6½ per cent.

The two chief applications of this alloy are as an energetic deoxidizer and for securing a better desulphurization.

This alloy contains the two elements most useful for the deoxidation of a metal (silicon and aluminium), and also calcium, which is a very energetic reagent. Added into the ladle it calms the steel and enables the tapping of sound ingots. The products of the reaction of this alloy are double silicates of calcium and aluminium, which have a low melting point, the slag rising to the surface of the steel.

This alloy is said to give better results than aluminium alone, even when it is added into the ingot mold itself, because it forms a very easily fusible slag which disengages from the steel.

The alloy may be introduced either into the furnace a short

...ture tapping, or into the tap-hole during the tapping, or even into the ingot mold instead of aluminium or together with aluminum.

Pyrometry in Relation to Boiler Plants.

By Chas. E. Foster.

...a boiler is, like most engineering works, a compromise. Here, as elsewhere, the battle is fought between cheapness on the one hand and efficiency in operation on the other. Allied to the forces working for cheapness is the desire that the boiler, with its accessories, shall occupy small floor space, and generally efficiency suffers rather badly in the encounter.

Frequently we see published the statistics of boiler designs, and among these will be found grate area and heating surface. We are told with great exactness how much room there is to spread the fuel and what is the area of the surface through which the heat from the fuel may get into the water. But very often the statistics are silent on another equally important factor—the cubic space allowed for the completion of combustion of the fuel.

The burning of fuel is a very complex process, of which really little is known, but we do know by experience that it involves several transitions or stages before the whole of the energy of combination between fuel and oxygen has been liberated. Combustion involves the establishing of reversible chemical changes, and the direction in which these proceed will depend on the temperature of the gases. Thus if we suddenly cool the flame in a boiler furnace by bringing it into contact with comparatively cool surfaces, we completely upset the progress of combustion. This is just what happens in a large number of boilers. There is not sufficient space given to complete combustion before the gases come into contact with the boiler tubes. The lower grade coals have a larger percentage of volatile matter, and require proportionately more combustion space.

So far the question has been glanced at from the point of view of the designer. There is, however, a much larger question, or rather one that affects a larger number of people, namely, those whose lot it is to control the firing of boilers as they are not always as they should be. Given a boiler with a combustion space too small for the duty expected of it, the obvious course is to so increase the air supply as to get a very short flame. But this plan defeats itself. Of course, if enough air is supplied we may be tolerably sure that nearly all the carbon has been burned to carbon dioxide and nearly all the hydrogen to water vapor. The trouble is that to insure this with a very short flame we must admit a large excess of oxygen, and with it four times its volume of inert and useless nitrogen, and as a result there is an enormous volume of gases to be passed through the tubes at a very high speed. This gives little chance for the efficient transfer to the water of the heat in these gases, and a lot of the heat goes into the flues. The draft has to be large to secure the necessary air supply. The boiler superintendent is truly on the horns of a dilemma, because to err in the other direction, reducing the air supply, is almost sure to allow much of the fuel to pass unburned and perhaps to choke up the heating surfaces.

Absence of smoke is no proof of proper combustion. There may be large quantities of carbon monoxide passing off invisibly. Measurement of the temperature in the flues, though valuable, is not conclusive evidence. Clearly, if there is a large volume of gases passing through the boiler their temperature may not be very high and still they may be carrying away a great quantity of heat. The smallest amount of air that will secure practically complete combustion is the condition to be aimed at, and the velocity of the gases should be as low as possible, so that they have time to burn and then time to give up their heat to the boiler.

To secure that adjustment of the draft and air supply which gives the highest temperature to the body of fuel will be the first step toward high efficiency. Therefore, a pyrometer is needed to measure the fuel temperature. If the boiler has any claims to good performance this temperature will be a high one, anywhere from 1400 to 1700° C. Now, such high temperatures cannot be measured with a Le Chatelier couple. No pyrometer that has to acquire the actual temperature to be measured can be used here. It is necessary, therefore, to adopt an instrument which measures the radiant energy given out by the fuel bed. This measurement may be made either with the total heat radiation as by the Fery radiation pyrometer or by the luminous radiation as in an optical pyrometer. The former method is much to be preferred because it does not require a skilled user, but can be satisfactorily used by the ordinary fireman, an advantage not possessed by any of the optical type.

In the December number of this journal the writer described the construction and operation of the Fery radiation pyrometer, and the details do not, therefore, need repeating here. It suffices to sight the pyrometer telescope through a small peephole into the boiler and a direct continuous reading is obtained showing, at will, the temperature of the fuel bed or the furnace walls, arches or other surfaces. Being portable, the pyrometer can be carried around the plant and set up where needed. Once set up, the readings are continuously given in temperature, direct, and may be autographically recorded where desired.

A New Burette Clamp.

A new form of burette clamp has recently been placed on the market by the Henry Heil Chemical Co., 210 South Fourth Street, St. Louis, Mo. This clamp has the usual iron body and thumb-screw by which the clamp is fastened to the rod of the support. The clamp itself is of stamped steel fastened to a steel screw. It is opened and closed by means of a cone-shaped iron nut which moves freely over the steel screw. The clamp is shown open in Fig. 1. By turning the nut so that it moves outward on the screw the cone engages the projecting ends of the clamp arms and forces them apart so as to close the

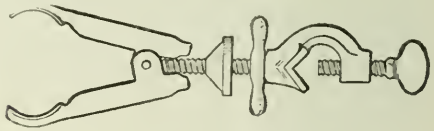


FIG. 1.—BURETTE CLAMP, OPEN.

jaws, as shown in Fig. 2. The clamp can be adjusted to hold a burette or condenser either upright, horizontal or at an angle by use of the check nut.

The obvious advantages of this arrangement are simplicity of construction and the central position of the steel clamp. The projection on the side, usually found with other forms of

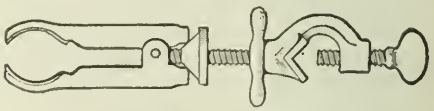


FIG. 2.—BURETTE CLAMP, CLOSED.

clamps, is thus done away with; this allows the chemist to quickly lock and unlock the clamp. The clamp is also cheaper than the usual form, as it contains less parts.

Vanadium Steel.—The United Steel Company, of Canton, Ohio, has received what is said to be the largest order for vanadium steel ever placed in this country, from the Ford Motor Car Company, of Detroit. This order calls for 2100 tons in all and includes vanadium steel for springs, vanadium case-hardening steel, and vanadium steel for axles, gears, etc. The new Ford car will be built throughout of vanadium steel.

Thermo-Electric Pyrometers.

To meet all conditions which arise in practice, the Siemens & Halske Co. is manufacturing all types of pyrometers—especially resistance pyrometers, thermo-electric pyrometers and optical pyrometers. A discussion of the special adaptability of these different types of instruments for different purposes may be found in a little pamphlet recently issued by the Siemens & Halske Co., in German, dealing with some typical applications of pyrometers, especially in blast-furnace practice, foundries, annealing and hardening furnaces, boiler plants, porcelain and stoneware factories, chemical works and glass works; in each case the most suitable type of pyrometer is pointed out. We intend to give a review of this very instructive pamphlet in our next issue. The following article is restricted to a description of the latest designs of thermo-electric pyrometers of the Siemens & Halske Co. Further details concerning these and other types of pyrometers made by this company may be obtained either from the Siemens & Halske Co. themselves at 50 Church Street, New York City, or by their sole agent, Mr Charles Engelhard, 32 Cortlandt Street, New York City.

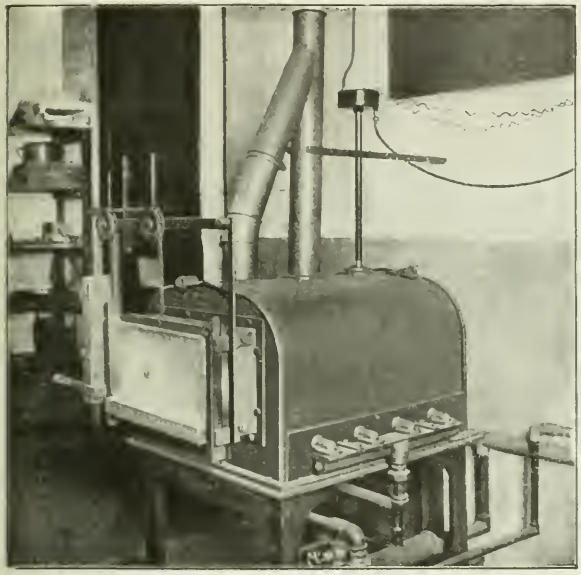


FIG. 1.—MUFFLE FURNACE WITH THERMO-ELEMENT.

The field of usefulness of the thermo-electric pyrometer is continually extending; it is used at present in smelting works for measuring the temperature of the hot blast in blast furnaces; in annealing and hardening furnaces; in porcelain kilns; chemical works; glass works; foundries; in steam-raising plants (for measuring the temperature of the superheated steam, flue gases, economizers, etc.), in refuse destructors, etc.

The advantages of the thermo-electric temperature measurement ensure its extensive use in the laboratory as well as in the factory on account of its adaptability to almost every requirement that may arise. Figs. 1 and 2 show the application of a thermo-element to a muffle furnace and a lead-hardening furnace, respectively.

The thermo-electric pyrometer consists essentially of three parts: the bulb, containing the thermo-element with protecting tubes and cooling device; the instrument which indicates or records the temperature, and the wires connecting the bulb with the instrument.

The indicator is made either as a direct reading apparatus for observing the temperature at any moment or as a combined indicating and recording instrument. The latter instrument affords a continuous check on the workmen day and night and enables the foreman to ascertain any irregularities in firing.

The adoption of the thermo-electrical pyrometer permits of having one indicating apparatus at a distance from the furnace (for example, in the engineer's head office), and another, connected in parallel to it, near the furnace, thus enabling the foreman to control the temperature. Further, it is not necessary to have an indicator for each thermocouple, as by means of a multiple-way switch any number of thermocouples, provided they are of the same type, can be used with one indicator, or a special switch can be supplied for affecting this interchange automatically, an arrangement which allows of up to five thermocouples being used with one recorder as described below.

Thus a large works could be equipped with one or more indicators for the use of the stokers, and another with or without an automatic switch and with a recorder in the office of the superintending engineer.

In selecting materials for the thermocouple it is of the greatest importance that the readings obtained at the highest temperatures should always remain constant.

Platinum and platinum rhodium conform to this requirement even at high temperatures; both metals can be obtained of great purity and their melting points are sufficiently high so that with such a couple a temperature of 1600° C. can be measured. The relation between the temperature of the hot junction and e.m.f. of the Siemens-Halske instruments is determined for every thermocouple by the German Reichsanstalt and the results are given on the certificate which accompanies the instrument. The limit of error at the temperature of 1000° C. is about 5° C.

In cases where platinum and platinum-rhodium couples are too expensive, thermocouples of platinum and platinum-iridium will be found reliable enough for all practical purposes up to about 1000° C., but this type is not accompanied by the certificate of the Reichsanstalt.

For measuring moderately high temperatures less costly metals are employed. Silver and constantan couples may be used for temperatures up to 650° C. The couples are supplied with a Reichsanstalt certificate: the accuracy is ± 1° C.

Thermocouples are employed for measuring not only high temperatures, but also very low temperatures, and for this purpose couples of copper and constantan are used for temperatures from — 100° C. to — 190° C., which is sufficient for all practical purposes. The couples are supplied with the certificate of the Reichsanstalt: the accuracy is ± 1° C.

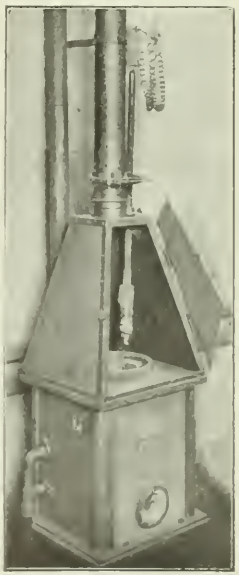


FIG. 2.—LEAD-HARDENING FURNACE WITH THERMO-ELEMENT.

Platinum, platinum-rhodium elements are, therefore, suitable [illegible] to 1600° C. (or about 400 to 2900° Fahr.); platinum-iridium elements from —200° to 1000° C. (or about 400

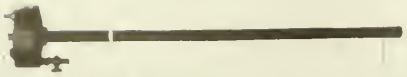


FIG. 3.—PROTECTING TUBE, WITH CAST-IRON COOLING HEAD.

to 1800° Fahr.); silver, constantan couples from +100° to 650° C. (or 212° to 1200° Fahr.); copper, constantan couples from —187° +100° C. (or —307° to 212° Fahr.).

The temperature range in which some type of a thermo-element can be used is, therefore, exceedingly large, extending

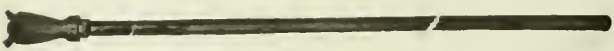


FIG. 4.—PROJECTING TUBE, WITH WOODEN HEAD.

from —187° C. to 1600° C., or from —307° Fahr. to 2900° Fahr.

The temperature which is measured by thermocouples is the difference between the temperature of the hot junction and the ends of the thermocouple where they are connected to the indi-

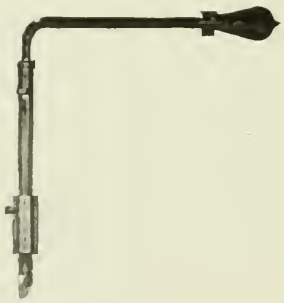


FIG. 5.—KNEE-SHAPED PROTECTING TUBE.

cator leads. In order to obtain accurate readings, the terminals of the couple must be kept at a low uniform temperature and protected from the direct radiation of the furnace. In general, this temperature can be taken as practically near enough to 0° C., and the reading shown on the indicator as that of the

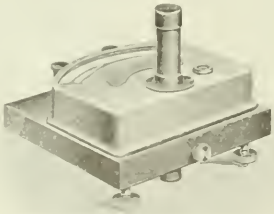


FIG. 6.—INDICATOR, WITH SUSPENDED COIL.

hot junction. For more accurate measurements, and especially at moderate temperatures, the temperature of the terminals of the couple cannot be ignored. For this purpose, an ordinary mercury thermometer is placed near the terminals, the temperature is noted and the indicator needle adjusted to show this temperature on the scale instead of 0° C., the indicator being disconnected from the couple at the time.

If this method be not followed, for temperatures above 100° C. about half, and for lower temperatures about the full temperatures of the terminals must be added to the readings of the indicator.

For high temperatures thermocouples should not be less than 1 m long, so that the junction is sufficiently far in the furnace to take the full heat therefrom. In using shorter couples the heat is liable to be transmitted to the terminals, thus causing errors. Generally the length of the couple depends upon the method of installing, but it is advisable to have the wires of the couple longer than the protecting tubes, using the surplus length in case of accident for renewal of the junction.

In order to secure the satisfactory economical working of an electrical pyrometer installation special care should be given to the manner in which the pyrometers are fitted up.

It is almost impossible to use thermocouples in a furnace without some method of protection. At the very least the two wires must be well insulated from each other. In addition to this, the thermocouple should be shielded against all mechanical injury, chemical action, and the deleterious influences of gases and vapors.

Platinum, at a high temperature, has a great tendency to combine with carbon and metallic vapors, its physical, chemical and also its thermo-electrical properties being thereby changed.

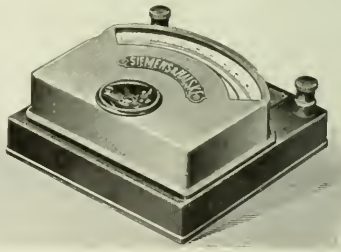


FIG. 7.—INDICATOR, WITH PIVOTED COIL AND HORIZONTAL SCALE.

Silver, copper and constantan must be protected, while hot, against oxidation.

The ordinary silk covering is only suitable as an insulation for the thermocouple wires at quite low temperatures. For higher temperatures, and not exceeding about 500° C., an asbestos covering often provides sufficient insulation. For still higher temperatures porcelain is almost universally employed, the Marquardt quality being especially suitable owing to its high fire-resisting and mechanical properties. This porcelain only becomes soft at temperatures above 1600° C. and even then shows no signs of electrical conductivity.

The usual forms adopted for this method of insulation are cylinders or spheres with two holes through which the thermo-

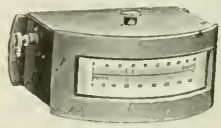


FIG. 8.—INDICATOR, WITH PIVOTED COIL AND VERTICAL SCALE.

couple wires are passed, or two concentric tubes are employed, one wire being passed through each tube and efficiently insulated from each other respectively. The Marquardt double tubes, when treated with fireproof glaze, have the further advantage of being highly impermeable to all gases. For temperatures above about 1200° C. they are a particularly suitable protec-

tion for thermocouples, but even then great care must be taken to avoid sudden variations of temperature in order to prevent the tubes from cracking.

Other insulating materials which are more rarely used for high temperatures are quartz-glass, carborundum, magnesia, etc., which have fire-resisting properties, combined with great power of resisting sudden changes of temperature.

At fairly low temperatures, that is below 1000° C. to 1200° C., it is usual to employ a metal sheath if there are no deleterious gases present, in order to combine better mechanical protection with a slower adjustment of temperature between the porcelain tube and the furnace. This sheath generally takes the form of a tube of iron, steel or nickel, which encloses the porcelain tube and protects it from mechanical shocks. Owing to its greater capacity for absorbing heat and its good heat conductivity, such a sheath also prevents sudden heating or cooling of the porcelain tube.

The instrument showing the temperature is either built as an indicator or a recorder. The indicators are millivoltmeters of the D'Arsonval type with moving coils situated between the poles of a permanent magnet. The high resistance of the instrument is advantageous in that the resistance of the leads connecting the thermocouple need not be taken into account. Consequently, leads of small sectional area can be used; even if of considerable length, it is not necessary to have their resistance calibrated, and a fresh thermocouple may also be used with the same indicator without being specially calibrated. Further, it is also permissible to connect several indicators to one thermocouple in order to observe the temperature from separate points and to connect several thermocouples to one indicator by the introduction of an ordinary multiple-way switch.

The indicators follow the variations of temperature quickly and correctly and they are almost dead-beat. They are made in various forms: the moving coil is either suspended by a thin metal strip (Fig. 6) or pivoted (Figs. 7 and 8); those instruments with suspended coils having the advantage of greater sensitiveness in consequence of the absence of friction and a higher resistance, while those with pivoted coils can be easily handled as they need not stand exactly level and are not so sensitive to vibration; they are especially useful in shops where large machines cause vibration.

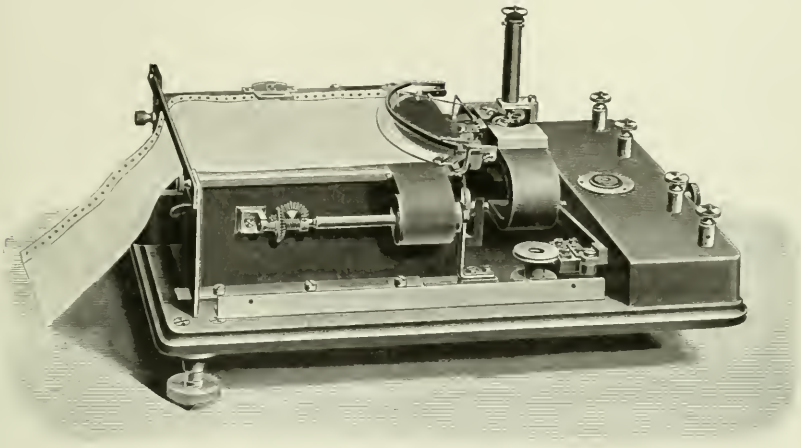


FIG. 9.—RECORDING PYROMETER (CASE REMOVED).

The recording pyrometer is shown with its case removed in Fig. 9. It is essentially an indicator, either with suspended coil or pivoted coil, provided with a special recording device.

Recently the recording pyrometers with suspended coil are also provided with an alarm bell which indicates when a dangerous maximum or minimum temperature is reached. For this purpose a contact device is used which closes a circuit containing the bell when the dangerous temperature is reached. This contact device is adjustable so that it may be set to any maximum or minimum temperature.

The recording device is so arranged that it requires very little attention.

When only occasional observations are to be made one temperature indicator may be used with a number of thermocouples by employing a multiple-way switch. But this switch is, of course, useless for recording instruments, as these are meant to give a continuous temperature record, so that in this case it would be necessary to have a recorder for every thermocouple.

FIG. 10.—AUTOMATIC SWITCH.

To overcome this drawback the Siemens & Halske Co. supplies an automatic switch (Fig. 10), which permits of up to five thermocouples being used with one recorder. Of course, the record for each single thermocouple is in this case not strictly continuous, since the instrument can only be in circuit with one couple at a time, but as the records of the different couples follow one another in regular succession it is quite easy to distinguish those belonging to any one thermocouple by the divisions on the chart.

Finally a potentiometer method for thermo-electric testing may be described, which makes use of a principle devised by

[illegible]. This method is used where such a degree of accuracy is required that the variation of the resistance of the thermocouple itself or of any other part of its circuit cannot be neglected.

The principle of this method is that of balancing the unknown e.m.f. of the thermocouple against an adjustable e.m.f., which, in its turn, is determined by a standard resistance and an ammeter.

In Fig. 11 *A* represents an accumulator, *W* a rheostat, *M* a milliammeter, *T* a thermocouple, and *G* a galvanometer. The

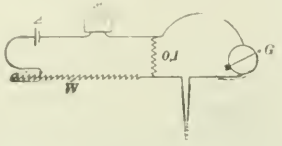


FIG. 11.—POTENTIOMETER FOR THERMO-ELECTRIC TESTING.

main current, the strength of which can be altered by the resistance *W*, produces at the ends of the fixed resistance of 0.1 ohm a potential difference which is exactly balanced by the unknown e.m.f. of the thermocouple when the galvanometer shows no deflection.

If very accurate measurements are desired, e. g., in physiological or thermo-chemical experiments, it is advisable to use a mirror galvanometer instead of a direct-reading galvanometer.

Metallic Sodium for Drying Transformer Oil.

Metallic sodium is made in this country at the works of the Niagara Electro Chemical Co., at Niagara Falls, by the well-known Castner process.

A novel application of metallic sodium, which will be of interest to the electrical industry, namely, for drying transformer oil to raise the insulating qualities, has recently been studied on a large scale.

The method of using sodium for drying hydrocarbon oils is one that is familiar to every chemist who has ever measured the dielectric constants of these oils where the sodium is usually added in the final operation to remove the very last traces of moisture. In the fear that the caustic formed by the reaction of the moisture on the sodium might be left as a liquid or a solid in the hydrocarbon, the chemist has usually thought it necessary to distill off from the sodium. In working on a very large scale this fear has been found to be groundless, and it is absolutely unnecessary to distill the oil.

Sodium has a density of about 0.97 at 15° C. (59° F.), and melts at 97° C. (207° F.). In transformer oil it will sink unless dragged to the surface by hydrogen gas. With water it reacts to form caustic soda and hydrogen. If very much water is present the caustic soda dissolves, and in the presence of oil forms a second layer. If very little water is present the caustic soda is formed on the surface of the metallic sodium and may be removed when removing the sodium. When the sodium surfaces become covered with caustic it is advisable to remelt under oil, not letting the temperature rise above 120° C. (248° F.). After cooling and getting into the shape desired it is again ready for use for drying more oil. Sodium should always be kept under a good transformer oil.

One method which has been used with transformer oils has been the following:

The oil on the granulated sodium is poured off and a good transformer oil poured over the metal. To the oil which is to be treated and which is put into an open tank or barrel, the sodium is added at first very carefully, about one ounce to the barrel. If much hydrogen is evolved, this will be conclusive proof that there is much water in the oil, and the balance of the sodium should be added carefully and in small amounts. The amount which is to be added depends upon the oil, but as a rule one pound to the barrel is usually much more than is required. The oil is then stirred up three or four times a day for a minute at a time. After several days the oil may be removed and tested, but the longer it remains over the sodium the better the oil becomes.

Another method used is to put the sodium in the form of sticks in a cylinder of iron wire of about 28 mesh and hang the cylinder in the oil. This method may be used directly with the static transformer which is in use. The only precautions required being those familiar to all electricians in the avoidance of short circuits.

The Niagara Electro Chemical Co. has repeatedly taken oils which broke down at 3000 volts and, by letting them stand over the sodium for two days, has brought the breaking-down point up to 20,000 volts or more. Results as good as this have been obtained on a large scale by one of the largest Niagara power companies.

Metallic sodium is sold by the Roessler & Hasslacher Chemical Co., of New York City, as agents of the Niagara Electro Chemical Co.

Coke-Oven Gas Electric Plant.

The London *Elec. Review* of Jan. 22 describes the Bargoed colliery installation of the Powell Duffryn Steam Coal Co. The mine has an output of about a million tons of coal per annum, and its power requirements for pumping, hauling, ventilating, screening, etc., are naturally large. At the Bargoed colliery the small coal, after suitable preparation, is turned into coke, the gases evolved being utilized partly in firing the ovens and partly in driving a large gas-engine plant for generating electrical energy to satisfy the power requirements of the colliery. The yield of gas is some 10,000 cu. ft. per ton of coal, having a heat value of 400 to 440 B.t.u. per cubic foot; the composition of the gas is as follows: Carbon dioxide, 2.01 per cent; oxygen, 0.42; carbonic acid, 5.21; ethylene, 0.80; hydrogen, 63.42; methane, 23.14; nitrogen, 5.0.

The gas is exhausted from the coke ovens and passed through the usual by-product plant, consisting of air coolers, water coolers, bubblers and scrubbers, water, tar and ammonia pumps, into a gas holder of 300,000 cu. ft. capacity, which will shortly be supplemented by a second holder. In order to avoid trouble from dust, the gas from the holder is passed through two groups of purifiers—in which it filters through layers of oxide of iron—prior to use in the large gas engines.

The purifiers, however, serve a double purpose, as the sulphur from the gas, which combines with the iron oxide, is utilized to make sulphuric acid in a suitable plant having a capacity of 10 tons of 70 per cent acid per 24 hours, and this acid is again used, together with ammonia liquor obtained from the gas, in a Wilton sulphate plant, which turns out some 5 tons of sulphate of ammonia per 24 hours.

The yield of ammonia sulphate per ton of raw coal put into the ovens is 19 lb., and of tar 36.5 lb., the respective values being approximately 45 cents and 6 cents.

The power-house equipment is of exceptional interest, as it comprises two double-acting four-cycle Nuremberg gas engines, one of 1200 hp and the other of 2400 hp. These gas engines are coupled with two alternators, the smaller of which has a capacity of 1100 kilovolt-amperes or 825 kw, with a 75 per cent power factor. The larger alternator has an output of 2200 kilovolt-amperes or 1650 kw, with a 75 per cent power factor. The gas engines normally run from Sunday afternoon to the following Saturday afternoon, the interval being utilized for cleaning, and it is usual to clean each cylinder from oil and gas remains every eight weeks. The running staff consists of a driver and cleaner by day and a driver only at night. The smaller 1200-hp engine generated during one year 3,872,000 kw-hours at a running cost of 0.114 cents per kw-hour, exclusive of the cost of gas.

Dangers of the Transport of Ferrosilicon.

With respect to the article on page 64 of our February issue, Mr. G. Watson Gray, consulting chemist of Liverpool, sends us a copy of a letter sent by him to a London *Times* Engineering Supplement, from which we quote as follows.

"It cannot be denied that serious accidents have occurred with some makes of ferro-silicon, but these have all occurred with the alloy containing 50 per cent. or thereabout of silicon, and then only with alloys made at some works, while certain other works making the alloy ever since its introduction have never had an accident or case of poisoning due to their alloy To me it appears most unfair that because accidents have happened with some makes steamship companies should refuse to carry ferro-silicon altogether, as it is making conscientious and skilful manufacturers suffer for the carelessness of unskilful manufacturers. If the alloy is made with due care with regard to the selection of materials, and under proper scientific control, as is the case at most works, it is a perfectly safe and harmless material. The alloy containing about 50 per cent. silicon has the property of disintegrating when left standing some time after being made, and it is during the disintegration that gases are evolved, if the ferro-silicon should contain any, but it does not follow that if the alloy disintegrates any gases are evolved. As this disintegration alloy is not so suitable for the purpose for which the substance is required, some of the larger manufacturers, following the suggestion I made at the meeting of the Iron and Steel Institute in 1904, have given up the manufacture of the 50 per cent. alloy and are making an alloy containing a higher percentage of silicon which does not disintegrate or evolve gases.

"Some of the letters which have apperaed in the newspapers would lead one to believe that the danger of the poisonous and explosive gases was in direct proportion to the amount of silicon contained in the alloy, but this is not so. It is only the 50 per cent. variety which has up to the present caused trouble. Ferro-silicon made in the blast furnace and containing only a comparatively law percentage of silicon, is quite safe to carry, as is the electrically-made alloy containing up to, say, 40 per cent. silicon, and also the alloy containing above, say, 60 per cent. silicon up to 99 per cent., the only quality which need be looked upon with suspicion being that containing between, say, 40 and 60 per cent. silicon, and even then only when it is made at certain works.

"This badly made alloy is dangerous to carry under any circumstances, and if packed, as has been suggested, in hermetically sealed iron drums, the danger of explosion would only be increased, as, in my experience, the presence of moisture is not necessary to cause an evolution of gas. If gas were evolved from material packed in hermetically sealed drums the risk of the drum bursting would be very great.

"Another point is that a number of people conclude that when an explosion of gas evolved from ferro-silicon occurs, it is due to acetylene generated from the alloy which has been made in a furnace previously used for the manufacture of calcium carbide, the alloy having thus become contaminated with carbide. As a matter of fact the largest makers of ferro-silicon do not make any carbide in the works in which the ferro-silicon, or other ferro-alloy is made, and my experience is that the danger is due not so much to acetylene as to phosphuretted and arseniuretted hydrogen. Before I discovered that phosphuretted and arseniuretted hydrogen were evolved from the ferro-silicon which exploded in Liverpool in January, 1904, I and my staff had seen opened and had sampled many thousands of casks of all grades of electrically made ferro-silicon, both in this country and on the Continent, and since the explosion my staff have dealt with larger quantities, as the production has increased during the last four years. None of the people have suffered any ill effects.

"High-grade ferro-silicon has become an absolute necessity in the manufacture of certain classes of steel, and as we have no facilities in England for the manufacture of this alloy, it must be shipped from the Continent; and in the interests of both our English steel manufacturers and the ferro-alloy makers on the Continent something might be done toward formulating some reasonable regulations with regard to the conditions under which the alloy should be carried, and the precautions necessary to be observed by the steamship companies in storing it."

Metal Statistics.

The **American Metal Market and Daily Iron and Steel Report** has just issued its "Metal Statistics" for 1909. These statistics appeared last year for the first time. The second edition is much larger and more complete. It can be safely stated that this little volume of 123 pages will prove very useful for buyers and sellers of metals. It contains tables and data on iron and steel, copper, tin, spelter, lead, silver, antimony, and two appendices of duties on metals, and on English and American price equivalents.

The chief new feature of this year's statistics are the 31 statistical tables on iron and steel, which have been compiled and arranged in a most creditable way by Mr. B. E. V. Luty of Pittsburgh. Several of these tables are of decided originality, like the table of "index steel prices" and the table of total production. The latter is herewith reproduced. It gives the estimated total production up to January 1, 1908, and the production in the year 1907 alone; gross tons except in the case of nails, which are given in kegs of 100 pounds:

	1907.	Total through 1907.
Iron ore	51,720,619	675,000,000
Pig iron	25,781,361	350,000,000
Open-hearth steel	11,549,736	72,000,000
Bessemer steel	11,667,549	145,000,000
Total steel	23,362,504	220,000,000
Iron rails	925	10,700,000
Steel rails	3,632,729	54,300,000
Structural shapes	1,940,352	19,000,000
Wire rods	2,017,583	21,000,000
Cut nails	1,109,138	200,000,000
Wire nails	11,731,044	147,000,000
Tin plate	514,775	4,950,000

Various facts revealed in this table are quite interesting, like the disappearance of the iron rail, and the fact that more cut than wire nails have been made, although now we make ten times the quantity of wire nails. (They date only from about 1886, whereas about the first finished iron made in this country was cut nails.)

The editors and publishers of these "Metals Statistics" must be congratulated on bringing out such a useful and interesting little volume.

National Chemical Societies

On Saturday evening, January 30, the monthly smoker of the Chemists' Club took place. The newly elected president, Dr. Morris Loeb, announced that Professor Morley had been elected an honorary member of the club in recognition of his splendid record in chemical research and his long and useful career as a professor

Dr. Baskerville, in a few words, then described the importance of the work Professor Morley has done for science Then Dr. Morley after receiving a beautifully illuminated resolution signed by all the members present, thanked the Chemists' Club.

Dr. W. R. Whitney, the new president of the American Chemical Society, was also a guest of honor, and Dr. Baekeland, as chairman of the New York section of the American Chemical Society, welcomed him to the club in a short speech, of which we extract the following, because it has a direct bearing on an editorial in our February issue.

"The American Chemical Society has entered upon a new era of unprecedented activity Thanks to the efforts of President Bogert, we have entered into a system of subdivision, which will give full scope to all the branches of chemistry in

[illegible] are engaged. After adding to our [illegible] very complete and useful Journal of Chemical Abstracts, we have now started a Journal of Industrial Chemistry and Chemical Engineering.

"It was very gratifying to feel after this excellent work had begun, that in a man full of keen activity and enthusiasm like Dr. Whitney, we shall find another able leader who will help to develop a brilliant future for our Chemical Society.

"Henceforth, every English-speaking chemist, whatever may be his specialty, ought to feel that it is his own interest to become a member of the Chemical Society.

"At the same time I shall take this occasion to state emphatically that I do not share the opinion of one or two of my friends who think that ultimately there will be no use nor excuse for any other chemical organization in the United States. Quite to the contrary, I believe that such societies as the American Electrochemical Society and the Society of Chemical Industry have abundantly proven their great usefulness and strong vitality. Even were it possible to consolidate with them, it would be undesirable because I believe that it would be harmful to the best interests of the future development of chemistry in this country. Consolidation or trustification may be an excellent thing for mediocrities, but can never do any good where individualism and superior personal effort show paramount.

"The Chemists' Club, bringing all the members of these different societies together has been the flux that strengthens the alloy which makes the backbone of our prosperous sister societies."

Advantages of Acetylene Lamps for Miners.

By A. Cressy Morrison.

For several years acetylene has been used in miners' lamps in France, Germany and Belgium to a large and steadily increasing extent, until at present it is used almost exclusively in over 200 mines and by approximately 50,000 men. The light is satisfactory, saves nearly 50 per cent of the cost, giving more and better light. Mining engineers have been more or less familiar with this fact, but the introduction of acetylene into mines, up to the last two years, has been very slow in this country. Its use is now, however, coming to be recognized as an important advance, and it promises shortly to replace all other means of illumination, except in special cases.

It is seldom that an improvement in quality or advantage is accompanied by reduction in cost, but this is really the fact in the case of acetylene.

Candles, which are largely used throughout our Western mines, remove seven times, and kerosene five times, as much oxygen from the air of the mines as acetylene. The products of combustion given off by candles are ten times and from kerosene nine times as much as that given off by acetylene. The difference in the deterioration of the air in the mines is, therefore, enormous. While acetylene in a mine gives off no smoke whatever, every miner is familiar with the difficulty from the products of combustion given off by other illuminants. Acetylene therefore, makes for the life and comfort of the miners, protects them from the degenerating effects of insufficient oxygen and removes the one important cause of lung and throat troubles. The actual amount of illumination given by candles and kerosene is reduced by a very large percentage by the smoke and soot which so rapidly accumulate, whereas all the light given by acetylene reaches the point to be illuminated, without any interference whatever.

It has been found, in actual experience, that in entries which are [illegible] of the air, there is not the slightest particle of smoke from the acetylene lamp and the entry is just as clean as it was at the beginning.

An interesting thing about acetylene is the tenacity of the flame. It is practically blown out, the rapid motion of the miner will not cause it to flicker badly, and it burns brilliantly in an atmosphere so foul that candles fade and go out. In fact, acetylene will not deprive the miner of light until the atmosphere is so bad it will not support life.

For underground surveying and mine inspection, the use of acetylene is of great importance. Maps and records escape the usual accompaniment of grease and smudge. The acetylene flame is so small and clear that it affords an accurate point on which to sight instruments.

Another use for acetylene in somewhat larger units is found where the rays are concentrated by a reflector, in which case a brilliant illumination can be thrown into inaccessible places where distant bays, high backs, caved places and other difficult and otherwise hidden parts of the mine can be explored with convenience, and in case of emergency, without danger.

Acetylene is especially advantageous as a cap lamp for drivers, and it has been found, where mules are used, that they can see much better and are not nearly so liable to stumble.

The very bad quality of oil for miners' use, which has in some States called for laws establishing a standard quality—laws, by the way, which are frequently violated by a species of adulteration which almost defies detection—is becoming another powerful argument in favor of the substitution of some illuminant which can not be adulterated.

In actual practice, 8 oz. of calcium carbide, at 4 cents per pound, or 2 cents' worth of carbide, will give nearly 10 cp of light for 10 hours, while candles in many parts of the country, counting four candles to the 10-hour day, would cost 5 cents per day. There seems, therefore, to be no reason why acetylene should not be introduced, provided a proper lamp at an economical price can be devised. As a matter of fact, practical experience has demonstrated that some of the acetylene miners' lamps now upon the market meet all the necessary requirements both as to economy, lasting quality and practicability in use. Miners' acetylene lamps are now frequently found in mines throughout the country, especially in Pennsylvania, New Jersey and Illinois. The New Jersey Zinc Co., of New York, which has adopted acetylene illumination for all its mines, has probably more lamps underground than any one concern. The number of miners' lamps in use in the mines of this company is about 3000, and it has been found, in practical use, that the saving is at least 2 cents per day for every miner. The whole method of using acetylene is so simple, and the lamps now in practical use are so satisfactory that the subject of better illumination in mines is worthy the attention of every mine owner and engineer; in fact, the obtaining of better illumination at half the cost, with greater output, safety, comfort and, above all, with better health to the user is so vitally important that the subject must be investigated soon by all mine managers.

Notes.

The **American Institute of Mining Engineers** started its New Haven meeting on February 24 with numerous papers discussing the comparative advantages of the sea-level and lock-type for the Panama Canal.

Cast-Iron Enamel Apparatus.—The almost unlimited possibilities of enamelled cast-iron apparatus for many purposes of the chemical industries are well known. Mr. J. W. Sittig, importer of German stoneware, states that he is now paying particular attention to the introduction of imported enameled cast-iron apparatus in this country.

The unsatisfactory **aluminium** market situation has resulted in the taking up of new electrochemical processes by aluminium manufacturers. This is no new development, as it will be remembered that the large aluminium works at Froges in Savoye were the birthplace of Heroult's work on ferroalloys and electric steel. It is reported that they are now also experimenting with the Guye process for making nitric acid for air. The same is reported from the Neuhausen aluminium company, where the Moscicki process is to be used.

Electric Zinc in Canada.—We have repeatedly noted the work of Mr. Fred. T. Snyder on the use of the electric furnace for zinc reduction. It is now reported that his process has been successfully reduced to commercial operation and that spelter and lead-silver bullion are being produced on a considerable scale at the electric furnace plant of the Canadian Zinc Company in Nelson, British Columbia. The ores treated average about 40 per cent. zinc, 10 per cent. lead and 12 ounces silver, with 1½ per cent. copper. The present furnace capacity of the works is 10 tons per day, but is soon to be trebled.

The **National Carbon Co.** of Cleveland had a fine exhibit at the recent electrical show in Chicago, showing a line of graphite and carbon electrodes for electric furnace work up to 10 inches square cross section and about 18 inches long. This is a stock pattern. They are made up to 12 inches diameter round. They also exhibited several carbon crucibles, carbon plates and ordinary electrodes.

The **Mechanical Appliance Company,** Milwaukee, Wis., exhibited at the recent Chicago Electrical Show an electric flour "sterilizer and ager" which has been built for the use of the Alsop Process Company. This sterilizer consists of an iron box containing revolving rollers which are connected to a high-pressure spark coil. Current for this coil is provided by a 500-volt generator which is located on top of the sterilizer. A current of air is provided in this sterilizer for blowing out the arc and carrying off the nitrogen oxide and ozone gases which are formed by the arc. These gases age and sterilize the flour by passing up through it.

Electric Steel.—According to the *Manchester Guardian,* a new plant for the electrical manufacture of steel has been set to work at Flekkefjord, in Norway. The method employed is that patented by Hiorth (described in our Vol. VI, p. 143). At first the output will consist chiefly of high-grade tool steel, though it is the intention in future to manufacture plates also. The iron is being imported from Sweden, and converted into steel in the electric furnace, the energy being derived from water power in the neighborhood. The enterprise is being financed chiefly by Dutch capital. No particulars are given as to the output. (Lond. *Electrician,* Jan. 29.)

Iron and Phosphorus.—A thesis of Dr. B. Saklatwalla, presented to the Institute of Technology of Berlin (Berlin, 1908), gives an account of a thermic and metallographic investigation of the compounds of iron and phosphorus. Great care was taken to use pure electrolytic iron and pure phosphorus, and exclude any carbon. The chief results are as follows: The melting point of a chemically pure iron in a nitrogen atmosphere is 1510° C. Phosphorus forms with iron up to 1.7 per cent a solid solution. This solid solution forms with Fe_3P a eutectics with 10.2 per cent phosphorus and a melting point of somewhat above 1000° C. Between Fe_3P and Fe_2P there exists a eutectics with about 16.2 per cent phosphorus and a melting point of 960° C. By melting between 20.5 and 21.7 per cent phosphorus, no eutectics is formed, but "mixed crystals." Between Fe_2P and the next higher phosphide there is probably again a eutectics with a melting point of 1218° C. The hardness does not increase directly with the content of phosphorus. The hardness has maximum values at the eutectic points.

Wisconsin Section American Electrochemical Society.—The Wisconsin section of the American Electrochemical Society has been holding regular meetings at Madison, Wis., during the last few months. At the December meeting Mr. James Asten presented a paper upon the subject of "the iron-carbon series of alloys." Mr. Asten is working with Prof. Burgess under the Carnegie Institute grant for research on electrolytic iron. At the January meeting Prof. C. F. Burgess read a paper upon the subject of "the corrosion of boiler locomotives." This subject was treated from the electrochemical corrosion standpoint. At the February meeting Mr. C. I. Zimmerman gave a talk upon the subject of "some electric furnace products from sand." The various products, such as carborundum, silicon, monox, fused silica, silundum, siloxicon, and the various silicon alloys, were briefly discussed.

The first issue of a new journal, "How," contains a suggestive note on an important improvement in a manufacturing process due to accepting the advice of a consulting chemist (who, in this case, was Mr. Fred J. Maywald). The note is significant of the increasing interest of the non-technical public and of general manufacturers in chemical engineering.

Mr. **C. O. Mailloux,** consulting electrical engineer of New York City, has opened in connection with a French electrochemical engineer, M. Delton, an international electrochemical engineering office with headquarters in New York and Paris. M. Delton has been identified with some of the most important electrochemical industries in Europe; he has designed, constructed and operated numerous electrochemical plants, and he is at present the technical adviser and consulting engineer of a large number of electrochemical concerns in various countries. The new consulting engineering firm has at its disposal practically all the experience and data of dozens of plants; not only the specifications, the general and the detail plans, and all the construction data, but also all the records of tests, and details regarding cost of production at every stage; also profits, etc. The following list gives the principal electrochemical processes on which the firm has reliable data. Production of pure alumina, artificial cryolithe, and aluminium; calcium carbide (electric furnaces up to 5000 kw); production of ferro-alloys, including ferro-silicon, chromium, manganese, molybdenum, tungsten, vanadium, titanium; production of steel by the electric furnace; production of phosporus by the electric furnace; electrolysis of sodium chloride by all processes, including diaphragm cells, mercury cathode cells, and gravity ("bell") cells; production of chlorine compounds; chloride of lime, hypochlorite of lime, chloride of sulphur; tetrachloride of carbon, chloride of lead; liquid chlorine; production of potassium chlorate, or sodium chlorate by direct electrolysis; extraction of sodium chloride, by multiple evaporation system; steam and hydraulic power plants for power transmission, and distribution, and for electrochemical plants.

The **National Council of Commerce** has just issued the *Proceedings* of its first annual meeting, held at the office of the Secretary of Commerce and Labor, in Washington, on Dec. 10, 1908. Secretary Oscar S. Straus made the chief address, outlining the scope of the new organization. According to the by-laws which were adopted the objects of the National Council of Commerce are (a) to receive reports and communications from commercial and other bodies as to their needs in the promotion of foreign and domestic commerce; (b) to receive and act upon information and suggestions from the departments of the United States government of interest to the business world; (c) to furnish the Secretary of Commerce and Labor and other representatives of the United States government with authentic information as to the needs and conditions of different industries; (d) to suggest special investigations abroad by agents of the Department of Commerce and Labor; (e) to act as an intermediary between that and the other departments of the United States government and the commercial and trade bodies in arranging for the representation of American products at international expositions; (f) to confer with the departments of the United States government with a view to promoting the trade interests of the country; (g) to confer with the Secretary of Commerce and Labor regarding legislation necessary to promote foreign and domestic commerce or adequately to equip his department for such work; (h) to promote friendly co-operation between commercial organizations throughout the United States. Eligible to membership are all commercial and industrial associations in good standing in the United States and similar associations in foreign countries composed of or controlled by citizens of the United States, residing and doing business abroad. The yearly

...ership fee is $100. Mr. Gustav H. Schwab, of New York City, is the treasurer of the council. Among the members of the council are the American Hardware Manufacturers' Association (Charles W. Asbury) and the National Wholesale Druggists' Association (Wm. Jay Schieffelin).

Personal.

Dr and Mrs **Paul Héroult** sailed for France on Feb. 18. Dr. Héroult intends to return to this country in three or four months.

Dr **Eugene Haanel**, Director of the Canada Department of Mines, Mines Branch, has returned from Sweden, where he investigated a new process of reduction of iron ore in the electric furnace at the works of the Electro Metal Co., Ludwika, Sweden. While it is reported that the results of the investigation have been very satisfactory, the first official account will be given in a report of Dr Haanel to the Canadian government.

Mr **Louis Simpson** has resigned as general manager of the Montreal Cotton Co., of Valleyfield, Quebec, in order to devote all of his energies to the promotion and furtherance of electric iron and steel industries in Canada.

Dr **Franz Meyer** has resigned as director and treasurer of the Metallurgical Co. of America and has returned to Germany to enter as partner into the firm of R. Wedekind & Co., in Uerdingen (Niederrhein).

Mr **I. J. Moltkehansen** has resigned as manager of the A. S. Vadheim Electrochemiske Fabriker, in Norway, and has established an office at Brussels, Belgium, as consulting engineer, especially for electrochemical industries desirous of acquiring cheap water powers in Norway.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Electric Furnaces (*Continued*).

585,040, June 22, 1897, C. G. P. De Laval, of Stockholm, Sweden.

Resistance type. A furnace for melting or heating metals and other materials. The furnace is a pot of iron lined with refractory material. In its lower part is a transverse bridge of refractory material, containing a water-cooled passage. The electrodes are horizontal iron bars of opposite polarity which extend through the sides of the furnace into the lower ends of the cavities at each side of the bridge. Sealed inclined tap holes for the molten metal extend through the opposite walls. In operation, the metal to be melted is introduced through a charge-opening in a cover lying on top of the furnace, comes in contact with the iron electrodes and is melted by resistance. If desired, an electrolyte, such as molten magnetic iron ore, may occupy the lower part of the furnace chamber, being heated by an alternating current passing between the iron electrodes. The metal to be melted is then fed into this electrolyte and is thereby heated. A lateral tap hole serves to maintain the electrolyte at a predetermined level. The electrolyte is used merely as a means of heating and effects no reduction.

586,686, July 20, 1897, Robert F. S. Heath, of Camden, N. J.

Arc type. This furnace, primarily for the production of calcium carbide, has a vertical cylindrical chamber with a non-conducting lining. One electrode is a horizontal circular metal ...containing a charge of broken carbon and rotating on a ...axis. The other electrode consists of a series of depending carbon bars, carried in an adjustable metal head. The lower ends of these bars extend over the hearth at one side only. A feed hopper discharges over the opposite side of the ...charge, the hearth electrode is slowly rotated; the ...charge is gradually fed in being distributed over the hearth by its rotation, and is reduced as it comes within the field of the arc. The molten carbide may be tapped out through a lateral hole in the hearth, or may be allowed to accumulate, the hearth then being rolled out of the furnace through a suitable door. The tap hole may be opened by forcing a pipe through a hole in the side wall of the furnace and into the tap hole, displacing its plug.

586,687, July 20, 1897, Robert F. S. Heath, of Camden, N. J.

Arc type. This furnace, primarily for the production of calcium carbide, consists of a vertical chamber of refractory material having a non-conducting lining. The cathode is a hearth of broken carbon. The other electrode is a series of depending carbon rods, carried by a metal holder, with their lower ends at one side of the hearth. A feed hopper extends to the other side of the hearth, having a cut-off valve and a conveying screw. The metal holder of the vertical electrodes is laterally adjustable in a bar which is vertically adjustable on a central rotating shaft. In use, the lower ends of the electrodes sweep over the hearth in an annular path; they are simultaneously raised as they rotate by automatic mechanism.

586,822, July 20, 1897, Francis J. Patten, of New York City.

Arc type. The furnace consists of a vertical chamber having a carbon hearth and a depending carbon electrode. The hearth is surrounded by a magnetic ring having a closed Gramme winding with four leads, supplying biphase alternating currents. An arc is sprung between the hearth and depending electrode, and is caused to rotate by the rotating magnetic field set up in the ring. In a modified construction, the depending electrode is a carbon tube, or two concentric tubes. Arcs are sprung between the lower ends of the depending carbon tubes and the hearth. The magnetic ring is protected from the heat by a wall of fireclay. The charge mixture may be fed into the furnace through the tubular electrodes. The molten product is withdrawn through a lateral tap hole at the base of the chamber.

586,824, July 20, 1897, Francis J. Patten, of New York City.

Resistance type. The furnace is a vertical chamber of brickwork having central carbon-rod terminals entering its base and top. A magnetic ring supplied with biphase alternating current surrounds the chamber. In use, a thin carbon pencil is placed between the carbon terminals or electrodes and the charge mixture, for example, lime and carbon, is fed into and fills the chamber. The carbon pencil is heated by resistance and reduction proceeds in proximity to it. Alternating current is simultaneously supplied to the magnetic ring, producing a rotating field which tends to deflect the current away from a vertical line joining the electrodes, and thus to force the zone of reduction outward into the unreduced charge. The resulting nugget of calcium carbide is withdrawn and the process repeated. The carbon pencil used to start the current is consumed, and a new one is inserted in recharging the furnace.

NEW BOOKS.

Laboratory Notes on Industrial Water Analysis. A survey course for engineers. By Ellen Henrietta Swallow Richards. 52 pages. Bound in cloth. Price, 50 cents. New York: John Wiley & Sons.

Foundry Practice. A treatise on molding and casting in their various details; prepared for the use of students in the College of Engineering, University of Minnesota. By Ja. M. Tate and Melvin O. Stone. 240 pages. Bound in cloth. Price, $2. New York: John Wiley & Sons.

Leather Industries Laboratory Book of Analytical and Experimental Methods. By Richardson H. Proctor. 480 pages. Bound in cloth. Price, $7.50. New York: Spon & Chamberlain.

Factory Glazes for Ceramic Engineers. Arranged (on an exhaustive method) for the heat of the soft porcelain kiln and including the glazes employed in actual manufactories by the

foremost manufacturers of the finest products; with improvements thereon and additions thereto. A of the series. Bound in cloth. Price, $10 net. New York: Spon & Chamberlain.

Hydraulics and Its Application. By A. H. Gibson. 773 pages. Bound in cloth. Price, $5 net. New York: D. Van Nostrand Co.

Modern Power Gas-Producer Practice and Applications. A practical treatise dealing with the gasification of various classes of fuels by the pressure and suction system of producer. By Horace Allen. 834 pages. Bound in cloth. Price, $2.50. New York: Van Nostrand Co.

The Economy Factor in Steam Power Plants. By G. W. Hawkins. Bound in cloth. Price, $3. New York: Hill Publishing Co.

The Steam Turbine. A practical and theoretical treatise for engineers and designers, including a discussion of the gas turbine. By Ja. Ambrose Moyer. 377 pages. Bound in cloth. Price, $4. New York: John Wiley & Sons.

Applied Mechanics for Engineers. A text-book for engineering students. By Lee E. Hancock. 396 pages. Bound in cloth. Price, $2 net. New York: Macmillan Co.

New Laboratory Manual of Physics. By S. E. Coleman. 264 pages. Bound in cloth. Price, 80 cents. New York: American Book Co.

Electric Motors; Their Installation, Control, Operation and Maintenance. By Norman Gardner Meade. 164 pages. Bound in cloth. Price, $1 net. New York: McGraw Publishing Co.

The Radioactive Substances, Their Properties and Their Behavior. By Walter Makower. 301 pages, illustrated. Bound in cloth. Price, $1.75 net. New York: Appleton.

Radio-Telegraphy. By C. C. F. Monckton. Bound in cloth. Price, $2 net. New York: D. Van Nostrand Co.

An Introduction to Practical Mathematics; With Diagrams. By F. M. Saxelby. 226 pages. Bound in cloth. Price, 80 cents. New York: Longmans, Green & Co.

Patents as a Factor in Manufacturing. By Edwin Jay Prindle. 141 pages. Bound in cloth. Price, $2. New York: Enginering Magazine.

The Delays and Defects in the Enforcement of Law in This Country. By W. Howard Taft. 23 pages. Paper binding. Price, 10 cents. New York: Civic Forum.

BOOK REVIEWS.

Metallurgical Calculations. By Joseph W. Richards, A.C., Ph.D., professor of metallurgy in Lehigh University Part III. Metals other than iron (non-ferrous metals). 208 pages. Price, $2. New York: McGraw Publishing Co.

This third volume completes Dr. Richards' monumental work. The first volume deals with chemical and metallurgical principles in general, the second volume with their special application to iron and steel metallurgy, and the third volume with applications to the metallurgy of the non-ferrous metals. The three volumes are paged consecutively, and the third volume contains an index for the whole work. The metals dealt with in this volume are copper, lead, silver and gold, zinc, mercury and aluminium.

An evidence of the appreciation of the work by the metallurgical world is the fact that translations of the book into four languages have been made. The first volume of an Italian edition has just appeared. A French translation is to appear in serial form in the *Revue des Mines et de la Metallurgie* and later in book form. The first two volumes of a Russian edition are in press, and a German translation is in preparation. The bulk of the work was published originally in serial form in Electrochemical and Metallurgical Industry, from March, 1906, to July, 1908

The Mineral Industry. Its statistics, technology, and trade. Vol. XVI: year 1907. Edited by Walter Renton Ingalls. 1127 pages. Price, $10. New York: Hill Publishing Co.

It is clearly an impossibility to review concisely a work of this size and scope. Besides, the general character of this annual publication is well known to everybody interested in metallurgy and mining. It must suffice to state here the chief impression which the reviewer received from a careful study of its contents. This is that the very high standard set by the late Richard P. Rothwell is being fully maintained by Mr. W. R. Ingalls with remarkable and even increasing success. The thanks of the metallurgical profession are due both to editor and publisher for this work which must be a work of love to a large extent, but which is a work of which the whole metallurgical profession of this country may justly be proud

* * *

Laboratory Experiments in Metallurgy. By Albert Sauveur, professor of metallurgy and metallography in Harvard University, and H. M. Boylston, instructor in mining and metallurgy in Harvard University. 73 pages, illustrated Price, $1.25. Cambridge, Mass.: The authors.

This work comprises notes on 26 carefully selected experiments in metallurgy. In each case concise instructions are given concerning the procedure to be followed, with useful tables and often with references to standard works or papers on the subject under discussion. For each experiment a blank is added which the student is intended to fill out as his report of the experiment.

Naturally, the work is limited in its scope, as it deals with 26 special experiments only, but these are well chosen, and conscientiousness in carrying them out will fully award the efforts of the student and will give him a grasp of at least some of the most important subjects of metallurgy. The work has been primarily written for the use of Harvard students taking the courses in general metallurgy and in the metallurgy of iron and steel. But the reviewer joins the authors in the hope that "these notes may prove suggestive, at least, to other teachers and students in metallurgy, and even to practitioners of the art."

The first 13 experiments refer to general metallurgy and deal with the following subjects: Coking and proximate analysis of coal; calorimetry (the Parr calorimeter); pyrometry (the Siemens water pyrometer); the Mesuré and Nouel optical pyrometer; and the Le Chatelier thermoelectric pyrometer); determination of the melting points of tin, lead and zinc, reduction of copper oxide by carbon; reduction of lead oxide by carbon; reduction of iron oxide by metallic aluminium (the thermit reaction); reduction of copper oxide by copper sulphide.

The second part of the book deals with the metallurgy of iron and steel and contains again 13 experiments. These are selected to illustrate the influence of carbon and nickel upon the tenacity, elasticity and ductility of iron, the thermal critical points of steel, and the changes in magnetic properties occurring at the thermal critical points; the relation between the critical points and the hardening power of steel; the brittleness produced by hardening and the hardness produced in high-carbon steel by sudden quenching from a high temperature; the influence of hardening upon the ductility, elasticity and transverse strength of steel; the influence of carbon upon hardness and hardening power of steel; the influence of the nature of the quenching bath upon the hardening of the steel, tempering of hardened steel; the influence of certain heat treatments upon the physical properties of steel, the effect of annealing upon the properties of cold-worked steel; the effect of heat upon the grain of steel.

Laboratory Guide of Industrial Chemistry. By Allen Rogers, Ph.D. 158 pages, illustrated. Price, $1.50. New York: D. Van Nostrand Co.

Dr. Rogers is instructor in industrial chemistry in the Pratt Institute, in Brooklyn. His book follows rather original lines, as indicated by the following remarks in the preface:

"In the average course of chemistry as taught in our tech-

[illegible] no attempt made to bring the [illegible] with manufacturing conditions. This [illegible] is exceedingly difficult to understand, when we [illegible] the little amount of time devoted to practical work [illegible] engineering courses.

"The factory is surely no less fertile a department of this industrial era than the railroad or the foundry. For in the manufacturing plant there is more need of techno-practical (if such a term may be used) trained men than in any other branch of industry. Unquestionably it is necessary to have organization for the manipulation of power, machinery and labor, so as to obtain the maximum of production with the minimum of expenditure or depreciation of plant. But in addition, it is highly essential that we understand the chemical principles upon which these industries are based.

"The object of this book, therefore, is to acquaint the student of chemistry with a few commercial processes, by introducing practical methods of handling materials on a large scale; the care and use of machinery; the cost of raw material; transportation, cage system; the handling of men and shop discipline.

"The subject-matter of this book presupposes a certain knowledge of chemistry, and purposely leaves many of the minor details to be worked out by the student. Great leeway is also given to the instructor in order that he may exercise his own originality."

The first chapter gives very brief notes on evaporation, filtration, etc., and deals especially with the various methods for determining the density of liquids.

The second chapter deals with inorganic preparations; aluminium sulphate, antimony-potassium tartrate, ammonium sulphate, barium chloride, etc. In each case the necessary quantities of the raw materials are determined and an estimate of the cost per pound is made. The author recommends to carry out his work on the "foremanship system."

One man is assigned as foreman of the "chemical works" and has as his assistants three or more of his classmates. The work which he is given may be the manufacture of barium chloride, for example. He first has his men make an analysis of witherite to determine the percentage content of barium and also test the strength of the hydrochloric acid. In order that the work may be more commercial he is told to estimate the cost of producing 15,000 lb., it being understood that all weighings are made in grams. The necessary quantity of mineral is then weighed, crushed and treated with the diluted acid in the kettle. During such a preparation as this it will be necessary to remove impurities, this being regulated by analytical tests.

The following chapters deal with the dyeing of textile fibers; the preparation of commercial organic compounds, coal-tar colors and synthetic oils; pigments and lakes; driers, varnishes, paints and stains; soap and allied products; leather manufacture; wood fiber pulp and paper. In each chapter references are added to standard works on the subject discussed.

The book is certainly very suggestive and a valuable contribution to the very scarce literature on the teaching of industrial chemistry.

* * *

Rapid Methods for the Chemical Analysis of Special Steels. Steel-Making Alloys and Graphite. By Charles Morris Johnson. 221 pages, illustrated. Bound in cloth. Price, $3. New York: John Wiley & Sons.

The rapid growth during the last decade of the industry of special steels, especially high-speed tool steels, has brought into existence quite a number of serious and difficult special problems of analysis which had to be solved by the chemists of special steel works. The book, here under discussion, is the first giving a systematic record of extended work in this field.

The author is the chief chemist to the Park Steel Works, of the Crucible Steel Company of America, and is, therefore, well qualified to write on this subject with authority. A large number of the methods described appear to be original with the author.

The book has 16 chapters, of which the first 13 deal with the following problems of analysis: Qualitative tests for chromium, vanadium, copper, titanium, nickel, molybdenum and tungsten in steel; analysis of vanadium steel and ferrovanadium; analysis of titanium steel and ferotitanium; analysis of tungsten powders; analysis of tungsten steel and chrome tungsten steel; analysis of low-percentage tungsten steel; analysis of molybdenum powders; analysis of tungsten-molybdenum steels; analysis of ferro-chrome, chrome ore and carbonless chrome; determination of aluminium steel; determination of copper in steel and pig iron; separation of nickel and copper from iron and vanadium by potassium ferricyanide; determination of copper in metallic copper; rapid determination of nickel in the presence of chromium, iron and manganese; analysis of ferromanganese; rapid volumetric method for manganese in the presence of iron, calcium and magnesium; determination of carbon in iron and steel by direct ignition with red lead or litharge; determination of carbon in steel, ferro-alloys and plumbago by means of an electric combustion furnace (also by gas and blast); carbon in steel by color; phosphorus in steel, pig iron, bar iron and wash metal; sulphur in steel, bar iron, pig iron and wash metal; manganese in special steels, bar iron and wash metal; silicon in iron and steel; analysis of graphite and graphite crucibles (containing interesting notes on the occurrence of carborundum in old plumbago crucibles).

The fourteenth chapter deals with the annealing of plain and special steels; much useful information is here condensed in less than nine pages. In the fifteenth chapter a simple method of calculation is described for finding the amount of water to be added to a concentrated solution in order to dilute it to a given lower percentage. In the last chapter the construction of a practical automatic steam water still and a simple laboratory method for making clay combustion boats are described.

* * *

Metallic Alloys. Their Structure and Constitution. By G. H. Gulliver, Lecturer in Engineering at the University of Edinburgh. 254 pages, 104 illustrations. Price, $2 net. Philadelphia: J. B. Lippincott Co.

This book is not a guide to the practical details of manufacturing alloys, but is an investigation of the theory of alloys on a systematic basis. Two preliminary chapters treat briefly of the theory of solution, of chemical equilibrium as applied to alloys, and the apparatus useful in the scientific examination and testing of the properties of alloys. This is followed by chapters discussing in detail illustrations of binary alloys in which no compounds are present, binary alloys in which definite chemical compounds exist, and ternary alloys of both kinds. The particular alloys described are chosen as typically illustrating the classes, and no attempt at a complete description of all known alloys is made. The work is therefore didactic rather than encyclopædic and must be thus judged. From this point of view it is decidedly a well-written book, adding very little to the store of known facts, promulgating hardly a new idea, but giving a well-balanced picture of the theory of the subject.

* * *

Practical Calculations of Transmission Lines (for distribution of direct and alternating currents by means of overhead, underground and interior wires for purposes of light, power and traction). By. L. W. Rosenthal. 93 pages Price, $2 net. New York: McGraw Publishing Co.

The chief mission of this book is to substitute a direct solution of calculating transmission lines for the trial method which was formerly a necessary evil. Within 93 pages the book contains an immense amount of formulas and tables.

The book contains six chapters, dealing, respectively, with direct-current distribution for light and power; distribution for direct-current railways; alternating-current transmission by overhead wires; alternating-current transmission by underground cables; interior wiring for alternating-current distribution, and distribution for single-phase railways.

Electrochemical and Metallurgical Industry

VOL. VII. NEW YORK, APRIL, 1909 No. 4

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH. D.....*President*
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Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, APRIL, 1909.

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A Symposium on the Electrometallurgy of Iron and Steel.

At the psychological moment a symposium on the electrometallurgy of iron and steel has been arranged for the first day of the May meeting of the American Electrochemical Society at Niagara Falls (the preliminary program being printed on page 146). In several steel plants in this country—and abroad even to a larger extent—the crucible process has been replaced by the electric furnace for the commercial production of high-grade special steels of crucible-steel quality. Further, the U. S. Steel Corporation has just adopted the electric furnace as an accessory to the Bessemer converter and open hearth, to produce large-tonnage steel products of greatly improved quality, especially rails and wire. Now, even the production of pig iron from ore in the electric furnace appears to pass from the experimental stage to commercial practice in two countries where the conditions appear especially favorable. As mentioned on page 146, a commercial electric-furnace plant for making pig iron and steel is to be started in Norway, and it is rumored that a large plant for the same purpose is to be erected at a favorable place in Canada as a result of the trip which Dr. Haanel recently made to Sweden to report to the Canadian Government on the furnace of the Elektrometall Company, Ludwika. The whole iron and steel industry is, therefore, just now immensely interested in the possibilities and actual accomplishments of the electric furnace. Much has been written and printed on this subject in recent years, and it has been the privilege of this journal to be the pioneer journalistic exponent of this new electrometallurgical industry, and to publish authoritative articles contributed to our columns by the leading electrometallurgists of iron and steel in all countries. But at the Niagara meeting of the American Electrochemical Society it will be for the first time that the whole subject is to be presented and discussed before a national engineering and scientific society.

* * *

While Dr. Héroult, of France, will probably not be present himself, a paper on the Héroult furnace and process will be presented by Mr. R. Turnbull, one of Dr. Heroult's chief engineers. It is the Heroult furnace that has just been adopted by the U. S. Corporation, and at the beginning of this year there were already in operation or in course of erection 19 Héroult furnaces with an aggregate charging capacity of 30 tons, and five Heroult furnaces the capacity of which had not yet been definitely decided. This does not include, of course, the new 15-ton Heroult furnaces of the Steel Corporation. Major Ernesto Stassano, the distinguished Italian pioneer of the electric iron and steel furnace, will himself be present at the Niagara meeting; this will be his first visit to this country. It will be remembered that Dr Hans Goldschmidt's report, made in 1902 to the German Patent Office on the Stassano process, was the first official document which attracted attention

...and changed ridicule into considera... At the beginning of 1909 there were 11 Stassano furnaces ... course of erection with an aggregate charging ... tons. A paper by Dr. F. A. Kjellin, the ... of the induction furnace, will cover the latest ... in the simple induction furnace and the Roechling-Rodenhauser combination furnace, of both types together there were in operation or in course of erection at the beginning ... year 20 furnaces with an aggregate charging capacity of ... tons. It may be remembered that in an 8-ton Roechling ... furnace considerable quantities of steel have been ... for rails of the Prussian railways. A paper by M. Girod, of France, will deal chiefly with his large and very interesting new electric steel plant, an illustrated description of which appeared in our January issue, page 9. At the beginning of the year there were in operation or in course of erection eight Girod furnaces with an aggregate charging capacity of 15 tons. Papers are also expected from M. Keller and M. Gin, well known metallurgists who have contributed much to the electrometallurgy of steel. Further, Mr. FitzGerald will give an analysis of the Lash process to explain more clearly what the Lash process is and why it may be of interest in the electric furnace. Finally, it is hoped that Dr. Haanel, Director of Mines of Canada, will not only attend the meeting, but present a paper embodying the results of his latest researches in this field in which he has done such important and effective pioneer work. To sum up, it will be seen that the program is thoroughly representative of the whole new industry, and we hope sincerely that the meeting will be attended by many practical steel men to participate in the discussion. For, as we have repeatedly pointed out, further progress depends chiefly on sound and healthy cooperation between electric-furnace engineers and practical steel men.

Bakelite.

In coining the name "bakelite" for the latest product of his inventive genius, Dr. Baekeland must have been conscious of the ... jokes he was inviting. But he must also have felt that the new stuff with its remarkable properties was worthy to ... his name down to future generations. Since we published Dr. Backeland's paper in our last issue, so many inquiries have been received at this office from most different quarters ... that it is hardly an exaggeration to say that bakelite is the most talked of chemical invention of recent years. That new interesting products may be obtained by reactions between formaldehyde and phenolic bodies has long been known, but Dr. Baekeland brought order into the chaos. His invention was not made at random, but is the result of a systematic study of the way in which the results vary with the conditions under which the reaction is carried out. His method of preventing dissociation ... furnishes of a porous solid, simply by working under ... in a "bakelizer," is as simple as ingenious. The existence of an intermediate product *B* between the initial condensation product *A* and the final product *C* seems at first to ... readers, but is really of immense importance, as it ... the molding operation. The molds are not ... while the change from *A* to *C*, but only for *A* to *B* ... *B* to *C*. It is very interesting to know that the synthesis ... by Dr. Baekeland in the laboratory seems to have a decided similarity to some intricate biological processes that take place in the cells of certain plants. Dr. Baekeland's new paper, to be presented before the Electrochemical Society in May, will certainly be awaited with great interest. We defer further comment until then.

Production Costs in the Steel Trade.

At the tariff hearings in November and December statements were made on behalf of the steel trade to the effect that there had been an enormous increase in the cost of production in the past 10 years. There was criticism of some of these statements in most quarters to the effect that they drew somewhat too striking a picture of the changes which had occurred. There is no doubt, of course, that the manufacturers endeavored to put their best foot forward, and there is no doubt, either, that they succeeded, so far as concerns the spreading of statements upon the records of the Ways and Means Committee. It appears, however, that they did not make so forcible a record upon the tariff bill which the committee produced. The committee made fairly radical reductions in the duties and showed a remarkable lack of apprehension of details by failing to classify merchant steel bars as they should be, as a finished product, but instead keeping them with billets and reducing the rate from $6.72 a gross ton to $3.92. It is not our purpose, however, to discuss the tariff bill. What we wish rather to point out is that since the general reductions in finished steel prices, dating from the decision on Feb. 18, to let the market seek a new level, the iron and steel trade has come to realize that there is somewhat more in the matter of increased costs than it realized last November.

* * *

It will be recalled that the lowest prices for finished steel products in the history of the industry were made in 1897 and 1898, principally in the former year. There was an increase of more than 2,000,000 tons, more than 20 per cent, in the production of pig iron from 1897 to 1898, although 1897 had been a record year, but the increase was not sufficient to engage all existing capacity, and the industry was still down on hard pan. In 1899, however, there came, in the market, a remarkable boom. The memory it left in the minds of those who participated was chiefly that of a remarkable increase in demand and production, with prices soaring sky-high. As a matter of fact, the increase in tonnage production from 1898 to 1899 was less than that from 1897 to 1898, and the percentage, of course, showed a still larger decrease, but the market found an enormous difference in the conditions, the difference between an insufficient demand, relative to capacity, and a slight excess of demand. The low prices of 1897-8, not the lowest prices done in any instance, but the lowest prices generally recognized in the market for any length of time in either of those years, were about as follows at Pittsburgh: Billets, $14; steel bars, 90 cents a hundred; plates and shapes, 95 cents a hundred; rails, $16; plain wire, $1.25 a hundred. Bessemer pig iron was sold at $8.75, valley furnace, and foundry and forge iron at slightly lower prices.

* * *

The boom of 1899 brought Bessemer pig iron to $24 at valley furnace, and Bessemer billets on round tonnages to $38, while

occasional prompt lots sold up to $44. Plates, shapes and bars sold at about 3 cents a pound for quick delivery. Rails were cheerfully advanced to $35, for the season of 1900, although the railroads did not take hold to any extent at that price. The boom of 1899 started a career of extravagance in the iron and steel trade, and except for occasional savings in new mechanical devices and improved processes, costs have been advancing almost steadily for 10 years. The depression of 1908 capped the climax, because the spirit of the times, not simply in the steel trade, but in most lines of endeavor, was to maintain prices of labor and commodities generally. With reduced tonnages and mixed specifications, and no offset by lower rates at any point, the steel trade found costs per ton of output higher in 1908 than in 1907.

* * *

It has not been alone at the works that costs advanced in the 10-year period. The railroads have advanced freight rates and the cost of assembling the large tonnage of raw material for the blast furnace has thereby been greatly increased. In the 10 years 1898 to 1907, inclusive, the United States made 181,470,757 tons of pig iron, the great bulk of which was made from Lake Superior ore, and the best ores in the region have been largely exhausted. The ores now mined are gained at greater cost in actual effort expended and are leaner, involving the assembling of a larger tonnage of ore, coke and limestone per ton of pig iron produced. These are actual material advances, and besides them there have been written into transactions other increases in cost. It is not much more than 10 years ago that Mesabi range leases, at the Minnesota State royalty of 25 cents, went begging, while to-day there are leases at close to a dollar a ton involving much less desirable ores. If prices lately made on finished steel products, $1.20 per 100 lb. on bars and $1.30 per 100 lb. on plates and shapes, are compared with the record low prices of 1897-8, they appear high, showing an advance of 30 to 35 cents per 100 lb., about $7.25 per gross ton. Relative to bare costs of manufacture, including wages and freights paid and materials consumed, the actual advance is very much less than this, while, putting the minerals at the values which have lately been assigned them, there has been practically no advance at all. In other words, at these new prices the steel trade is doing not a great deal more than obtaining returns to meet its increased costs and the values it has written upon its minerals.

* * *

The costs will, and must be, reduced, although the tendency to reduce wages, an unpleasant necessity, of course, does not seem to be as marked as it should be. In some branches there has been more disposition to reduce salaries, and this is not as it should be. The steel industry is destined to undergo great changes in the next few years, and will require more brains than it has lately. The readjustment will necessarily be slow. Comparisons with the low prices of 1897-8 must take into account the fact that it required four years of adversity, after the panic of 1893, to develop the low costs on which those prices were based. The trade needed tonnage as badly in 1894 and 1896 as it did in 1897, and much more badly than in 1898, but it was not then in position to make the low prices. The work was not done in a year, and cannot now be done in a year.

"Social Engineering."

Such is the title of a very interesting new book which will be found reviewed in the "Book Reviews" of this number. The expression gives us some reflections. All Americans are either employers or employed. The relations between these are of vital interest to everybody. Some, in fact, many of us, belong to both classes. It is well worth considering carefully and trying judiciously to improve these vital relations. As employees, our duty and best interest lies in giving our employers *more* than they pay us for, in rendering abundant and willing service. If I do one dollar's worth of work and my employer pays me one dollar, we are quits; value has been received and the transaction is closed. But if I return him more than one dollar's worth of service, the transaction is not closed; the extra service is not paid for at once in coin of the realm, but is stored up as obligation, to be paid later in the form of consideration and promotion. Let our younger employees in particular remember this, that promotion is the wage and reward of superabundant, unpaid-for service, and that this compensation is as sure to come as the usual monthly check or Saturday-night envelope. It comes to him who waits and who "hustles while he waits."

* * *

About employers, however, we wish to speak more fully. The average wage earner is underpaid. The terrible, impersonal law of supply and demand applies to labor and wages, and the comfort and well-being of the majority of mankind are at its mercy, however pitiless that may be. And herein lies the first principle of humanizing treatment of employees, namely, to moderate as far as possible the mercilessness of this law. Only humanitarianism, the brotherly instinct, can do this; love of gain works the other way. What should be the fair, proper wage to pay our employees? What they are forced to work for, by the law of supply and demand, the exigencies of daily bread, or shall it be "what we can afford"? And herein lies the true brotherly spirit, to compensate your employee not according to his necessity, but according to your ability. Let us think this out. Is there any obligation to do this? No legal obligation; only the moral force of the word "ought."

* * *

But will employees appreciate this new principle, will they respond to its kindly motives, will they really be bettered by it? Who can doubt it? Our working classes feel too often the sharp prod of necessity; they all too often need more and better food, clothing, shelter, sanitation, amusements, education, moral uplift. All of these are made possible by higher wages and considerate treatment by employers. The employer must feel that, of all classes of men, he is particularly his brother's keeper. But what if such altruistic, liberal treatment is not appreciated, what if it is abused, scorned, the kindly attitude misconstrued and ingratitude returned for thoughtful consideration? Well, that does not change one iota the moral obligation of the employer. What is done for goodness' sake must be done independent of thought of reward, or appreciation, or whatever may result. Give your employees all that you can afford to give them, wages, time, consideration, brotherly sympathy—and have your conscience commend.

Program of Niagara Meeting of American Electrochemical Society.

The [illegible] meeting of the American Electrochemical Society, which will be held in Niagara Falls, Canada, on Thursday, Friday and Saturday, May 6, 7 and 8, is already attracting the widest attention.

A special feature of particular interest will be a symposium of papers on the electrometallurgy of iron and steel. The whole first day (May 6) will be devoted to this subject. The papers will be presented in the morning, and the discussion will take place in the afternoon. There are papers promised by Dr. Eugene Haanel, Dr. Paul Heroult, M. Paul Girod, Dr. F. A. Kjellin, M. C. A. Keller, M. Gustave Gin, Mr. R. Turnbull, Capt. Ernesto Stassano and Mr. F. A. J. FitzGerald. We comment on this feature of the program on our editorial pages.

Other fields of electrochemistry will, however, not be neglected. Among the papers which have been promised for presentation on Friday and Saturday are the following:

"Electrochemical Methods of Soil Analysis," by Dr. F. K. Cameron.

"The Chemical Electrolysis of Acetates," by Prof. W. D. Bancroft.

"Addition Reagents in Plating Baths," by Dr. E. F. Kern.

"The Electrolytic Deposition of Platinum," by Mr. McCaughey.

"On the Deposition of Some Metals from Acetone Solution," by Dr. H. L. Patten and Mr. W. R. Mott.

"A New Radiation Pyrometer," by Mr. Chas. E. Foster.

"The Automatic Registration of Temperatures," by Dr. E. F. Northrup.

"A New Type of Ammeter for the Accurate Measurement of Alternating Currents above 1000 Amperes," by Dr. E. F. Northrup.

"Furnace Electrode Losses," by Mr. C. A. Hansen.

"The Relative Efficiency of the Arc and Resistance Furnaces for the Manufacture of Calcium Carbide," by Prof. S. A. Tucker, Mr. W. A. Alexander and Mr. H. K. Hudson.

"The Deposition of Aluminium from Aqueous Solutions with the Use of a Rotating Cathode," by Prof. S. A. Tucker and Mr. J. G. Thomssen.

"The Uses of Bakelite for Electrical and Electrochemical Purposes," by Dr. L. H. Baekeland.

"The Probable Electrical Nature of Chemical Affinity," by Prof. A. H. Patterson.

"Standard Cells," by Dr. F. A. Wolff.

On the evening of Thursday the address of the retiring president will be delivered by Dr. Edward G. Acheson, president of the International Acheson Graphite Co.

Arrangements will be made at the Clifton Hotel for exhibits of electrochemical and electrometallurgical products, particularly iron and steel produced in the electric furnace. Members may submit exhibits. Arrangements should be made with Mr. F. J. Tone, Carborundum Co., Niagara Falls, N. Y.

The meeting will be held at the Clifton Hotel, overlooking the Horseshoe Falls, on Canadian soil.

The Niagara Falls Committee also makes great efforts to render the social functions of the meeting as attractive and enjoyable as possible. There will be a smoker on Thursday night, after Mr. Acheson's presidential address, and a banquet on Friday night.

The afternoons of Friday and Saturday will be devoted to excursions and visits. One of the newer large electrochemical works, which started operation after the last meeting of the society in Niagara in 1903—the plant of the Funding & Development Company producing caustic soda and chlorine by the Townsend process—will probably be open for inspection.

On Saturday night a gorge trolley ride will be made, to be followed by an informal entertainment.

The membership of the society has now increased above 1000. Dr. E. G. Acheson, of Niagara Falls, is the president, and Dr. J. W. Richards, Lehigh University, South Bethlehem, Pa., is the secretary of the society.

An Extravaganza Night at the Chemists' Club.

The monthly smokers of the Chemists' Club of New York City have always had the distinction of being exceedingly enjoyable and democratic affairs, productive of good fellowship and promoting a better understanding between all classes of chemists represented in the membership of the club.

At the smoker of Feb. 27 the club ventured for the first time upon the field of extravaganza and did so with immense success. A "sole session" of the "Komists Club of Manahatta" had been called, and the following list of papers had been announced:

Theodore Roosevelt: "Non-stoechiometrical Combination of Undesirable Elements."

Marsten T. Bogert: "Natural Resources of Conversation."

William H. Taft: "New Researches in the Fatty Series."

Thomas J. Parker: "On the Use of Ni in Medal Production."

William J. Bryan: "On the Sodium Chloride and Magnesium Sulphate Content of a Certain River."

Albert P. Hallock: "On Methods of Extracting Rebates from Gas-Charged Artificial Waters."

Maximilian Toch: "A Paint that Won't Come Off."

Jokichi D. Takamine: "The Japanning of China."

Those who actually presented "papers" were the president of the club, Dr. Morris Loeb, Dr. Hugo Schweitzer, Dr. Leo Baekeland, Dr. M. T. Bogert, Mr. T. J. Parker, Dr. R. W. Moore, Dr. Maximilian Toch and Dr. J. D. Takamine.

The attendance was very large and exceedingly appreciative. Refreshments "warranted poor food by Dr. Wiley" were served to the survivors.

Electric Pig Iron Plant in Norway.

The Aktiebolaget Elektrometall, of Ludvika, Sweden, will erect in Norway what will be the first electric smelting plant in the world for the production of pig iron on a commercial scale.

The first installation will be built this summer, and includes two iron-ore reduction furnaces of 2500 hp each and two steel furnaces of 600 hp each. All furnaces will be operated with two-phase current. The plant will later be enlarged by erecting four more iron-ore reduction furnaces of 2500 hp each and four steel furnaces of larger size than 600 hp.

At present the drawings and specifications for this plant are worked out. Besides the electric smelting and refining plant the installation will include a rolling mill. The plant will be erected in a perfectly modern and commercial way, as everything is newly designed.

For this information we are obliged to Dr. Eugene Haanel, who recently investigated for the Canadian Government the electric reduction furnace developed by the Aktiebolaget Elektrometall at Ludvika.

New York City Proposed for the 1912 International Congress of Applied Chemistry.

In our March issue, page 104, we reported on a preliminary meeting at which the project was discussed to issue an invitation to the London International Congress of Applied Chemistry (to be held this spring) to hold the next congress, in the spring of 1912, in New York City.

A general meeting of representatives of American educational institutions, scientific organizations, manufacturing corporations, etc., has been called for April 3. The meeting will be held at the Chemists' Club, New York City. Dr. Hugo Schweitzer is the secretary of the temporary committee.

New York Section American Electrochemical Society.

A well-attended meeting of the New York section of the American Electrochemical Society was held on March 1 at the Chemists' Club, New York City. Dr. Chas. Baskerville was chairman and Mr. A. von Isakovics, secretary.

Two very interesting papers were presented, the first, by Dr. Frank K. Cameron, of the U. S. Department of Agriculture, on "Electrochemical Methods in Soil Investigations"; the second, by Dr. L. H. Baekeland, on "The Uses of Bakelite (see our March issue, page 111) for Electrical and Electrochemical Purposes." Since both papers will also be presented at the general meeting of the American Electrochemical Society, at Niagara Falls, in May, we defer our report until that time.

Nitric Acid from Air.

General Director S. Eyde, well known as one of the inventors of the Birkeland-Eyde process for the fixation of atmospheric nitrogen, presented on Feb. 13, 1909, a paper in Christiania before the Norwegian Society of Engineers and Architects. The paper is printed in the Norwegian paper *Aftenposten* No. 87, Feb. 13, 1909; a German translation may be found in the *Zeitschrift f. Electrochemie*, March 1, from which the following notes are prepared:

About $6,300,000 have been invested so far in the Norwegian nitric acid industry in the plants at Notodden and Svalgfos and at the rivers Rjukan and Vamma. By the end of 1910 these plants will be complete and the investment will then be about $15,000,000.

The Notodden plant has met with unexpected difficulties. Three months after starting the generators broke down. Nevertheless, the year 1908, which was the first year of operation, yielded a total income of $536,000. After deducting the expenses of the operation, general expenses and amortization there remained a net gain of $134,000.

The companies interested in the Birkeland-Eyde process have reached an understanding with the Badische Anilin und Soda Fabrik which has developed another process. The results which will be obtained at an experimental plant now in course of erection at Notodden will decide whether the furnace of the Badische Company or the furnace of Birkeland and Eyde shall be used for the final large plant for which money has been procured by the co-operation of the two companies.

The Iron and Steel Market.

The month elapsed since our last report was written has fully justified the early opinion that the declaration of an "open market" in steel products really meant nothing but the dropping of prices, in various lines, to new levels, which would be held with as much uniformity as had been the case with the previous prices. There have been no additional reductions in the lines which had developed new prices at the time our last report was written. Plates and shapes remain at 1.30 cents a pound and bars at 1.20 cents a pound, while steel pipe continues at the nominal discount of 80 off list.

No reduction has been made in wire products, and the prospective reduction may be delayed for several weeks, as it is desired to allow jobbers to reduce their stocks. Wire products are on the basis established by the $2 a ton reduction of June 9, 1908, following the $1 a ton advance of Sept. 3, 1907.

Sheets have dropped from $3 to $6 a ton from former official prices, while tin plates have been reduced 25 cents a box.

As was noted from time to time, the old prices were shaded more or less. Compared with the old nominal prices the reductions have been as follows, per ton of 2000 lb.: plates and shapes, $6; steel bars, $4; steel pipe, $10 on sizes ¼ in. to 6 in., but $8 on some other sizes; sheets, an average of about $4 on black and $5 on galvanized; tin plates, $5. These lines comprise about two-thirds of the total finished steel tonnage, the lines not thus far reduced, wire products and standard rails, comprising about one-third. Giving each reduction a weight equal to the tonnage output of the product, the average reduction in the lines reduced may be stated at about $5.50 per net ton. Inasmuch, however, as there has been more or less shading for months in several of these lines, the reduction from the actual market can hardly be estimated at more than $4 a ton.

The new sheet market did not develop as rapidly as did the market on plates, shapes, bars and pipe. The old schedule of differentials between gages had become somewhat unsatisfactory in both black and galvanized sheets, and the market had to develop some new differentials. A meeting of independent manufacturers was held, in view of the fact that the leading interest no longer had an "official" price, and adopted, as the nominal official prices of the independents, a schedule involving the changes in differentials which the leading interest had just adopted. The basis thus adopted was 2.30 cents per pound for black and 3.30 cents for galvanized, No. 28 gage, the former official prices (subject to a 5-cent rebate) being 2.50 and 3.55 cents. In black the differential between 28 and 29, and between 28 and 27 gage, was reduced from 10 cents per 100 lb. to 5 cents, while in galvanized the differential between 28 and 29 gage, and between 16 and 17 gage, was reduced from 15 to 10 cents. Thus, the reductions from the former net official prices, in this schedule, are $3 a net ton on black and $4 a net ton on galvanized, for 28 gage, while the reductions on 29 gage and lighter are a dollar more, and on black 27 and heavier and on galvanized 16 gage and heavier, a dollar less. The new official prices are only supposed to obtain on carloads; on attractive orders they are shaded $1 to $2 a ton according to circumstances.

The iron pipe manufacturers have reduced their regular list by two points, about $4 a net ton, in contrast with the five-point reduction in steel pipe. The Eastern manufacturers made a somewhat larger reduction. On account of the cost of raw materials and the high labor cost in making iron pipe it was impossible to make as large a reduction as was made in steel pipe.

The tin plate reduction was announced by the American Sheet & Tin Plate Co. on March 10 and promptly met by the independents. There has been a period of uncertainty during which the manufacturers insisted there would be no reduction. There had been no shading whatever in tin plate, and the reduction was made solely in order to bring out more tonnage. This, indeed, was the principal reason for all the reductions. There had been shading in a number of the products, but that shading was not the chief cause of the general reduction.

The crude steel market gradually settled down to a reduction of $2 a ton in both billets and sheet bars, making billets $23, f.o.b. Pittsburgh, and sheet bars $25.50, delivered Pittsburgh. The system of adding half the freight from Pittsburgh was abandoned, and this has thrown the market open, at distant points, so that the few sales made have not, as a rule, been at the full freight advance above Pittsburgh. It has even been reported that the $25.50 delivered price on sheet bars in the "zone" has been cut by about 50 cents.

Partly by reason of rather aggressive shading by some Western interests, and partly as a recognition of the growing importance of the Chicago district as a producing center, the freight differential above Pittsburgh has been partly abandoned and prices have been somewhat irregular in the West. Most business in plates, shapes and bars has probably been done at a 15-cent advance at Chicago, the freight being 18 cents from Pittsburgh.

Business was practically suspended in steel products immediately after the decision of Feb. 18 to let the market seek

[illegible] March a moderate amount of buying appeared, and the business increased, but it has hardly brought the [illegible] to the average of the first six weeks of the year. The [illegible] however, are accompanied by specifications [illegible] refusing to take extended contracts.

There has been a disposition on the part of buyers to await lower prices than those lately developed and to buy only for immediate necessities. The business of the country generally is awaiting the settlement of the tariff. The steel industry is not especially perturbed. It recognizes that the rates of the Payne bill are the minimum and that any changes made will in all probability be in the nature of increases. The trade is more concerned in having the matter out of the way than of having the rates advanced. With the exception of merchant steel bars there would be little danger of imports, with the Payne rates, now that domestic prices have been so reduced. The tariff matter is acting as a drag on business generally rather than on the steel trade in particular.

There has been a fair amount of activity in New England at the expense of prices, the Southern furnaces making sales on the basis of about $11.50, Birmingham, against $13 at the beginning of the year, while Buffalo and nearby furnaces met the delivered prices by making sales at the equivalent of about $14 at furnace. In the Central West there have not been enough sales to establish a definite market, but prices have been obviously weak, and from 25 to 50 cents less can be done on most grades than a month ago. Approximate quotations, f.o.b. valley furnace, may be named as follows: Bessemer, $15.50; basic, $14.75; No. 2 foundry and malleable, $14.50; forge, $13.75. Prices delivered Pittsburgh are 90 cents higher.

CORRESPONDENCE

The Electrolytic Reduction of Aluminium as a Laboratory Experiment.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—I have read with great interest the article in your January issue (this journal, Vol. VII, p. 19, 1909) from the pen of my friend Dr. M. deK. Thompson.

Firstly I may say that Mr. Thompson has performed an undoubted service by unmasking some of the difficulties which lurk in the way of the reduction of aluminium on a laboratory scale difficulties which have militated against a detailed study of the Hall and Heroult processes which is so urgently needed.

That it would be possible for one investigator to "easily reproduce" the results of a colleague, scarcely seems probable in the case of a process so dependent for success on the exact balancing of various factors as in that under consideration. Even Haber and Geipert point out (*Zeit. f. Elektrochemie*, Vol VIII, 1902) the influence of the relative dimensions of their apparatus and there can be no doubt that by substituting highly heat-conductive graphite for amorphous carbon, Mr. Thompson largely altered this influence.

Coming now to the most interesting portion of Mr. Thompson's paper, namely, his reference to what he terms the "anode effect," I do not think that Mr. Thompson's observation of this phenomenon is unprecedented. Thus, for instance, Winteler states on page 73 of his pamphlet "Die Aluminium Industrie" (Braunschweig, 1903) that the normal voltage on an aluminium furnace is 7 to 8 volts, but that as the alumina in the bath is consumed, the voltage rises and is only brought down again by the stirring in of fresh alumina. There can be little doubt that this was the cause of the phenomenon observed by Mr. Thompson. This would explain the fact that every time fresh cryolite containing alumina was added, the electrolysis started up again. The appearance of the anode as described by Mr. Thompson is a further confirmation of this view:

"It seems that where it dips into the melted cryolite a film of gas covers it, insulating it from the cryolite."

In their article on the electrolysis of pure cryolite (*Ann. d. Chem.*, 320, p. 237, 1901) Muthmann, Hofer and Weiss state that the anode is not "wetted" at all by the molten cryolite and that the current enters the electrolyte by means of innumerable tiny arcs. It would be interesting to learn whether Mr. Thompson observed this arcing.

Coming now to the individual experiments:

It is scarcely conceivable that a perfect solution containing 20 per cent of alumina was obtained at a temperature so low as 910° C., although a recent article by Moldenhauer (*Metallurgie*, 6, 14, 1909) lends color to Mr. Thompson's view. It is most unfortunate that further temperature measurements are not given, as these would have been of the greatest interest to those concerned in the manufacture of aluminium. It would also have been of interest if the quantity of cryolite used for each experiment had been stated.

That the "anode effect" should have appeared in experiment II immediately after the addition of 30 grs. of Al_2O_3 is at first sight not consonant with the opinion expressed above as to the cause of the phenomenon. However, in view of the effect of temperature and circulation on the rate of solution of alumina in cryolite this fact is perhaps not surprising. The influence of this latter condition is well seen in experiment III, where some parts of the bath showed the anode effect while others were working normally.

May not the "thickening" of the bath, described in experiment III, have been due to the sudden cooling of the flux which must have resulted from the reduction of the current? This would cause precipitation of alumina from a solution supersaturated at the lower temperature.

In conclusion I would draw attention to the fact that in experiment III the phenomenon was observed less frequently during the latter part of the run than at the commencement. This appears to point to the conclusion that during the earlier stages of the experiment, although electrolysis was proceeding the electroylte was becoming richer in alumina until a state of equilibrium had been reached. I hope to be in a position to treat this question quantitatively on some future occasion.

LONDON, ENGLAND. RICHARD SELIGMAN.

Steel from Ore in the Electric Furnace.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—For some reason Mr. Stassano seems to be under the impression that in the remarks I have made on the Lash process, the intention is to criticise his work adversely. Nothing could be farther from my intention, as I have the highest admiration for the excellent work Mr. Stassano has done in the electrometallurgy of steel.

On the other hand, Mr. Stassano did criticise the Lash process adversely, and I merely attempted to show in what way it might be advantageous. I do not think that as yet it has been shown that the advantages are non-existent. Probably, however, the Lash process has not been explained with sufficient clearness and, therefore, so far as it is concerned it is proposed to present a paper on the subject at the forthcoming meeting of the American Electrochemical Society.

As regards my assertions as to the cost of power, about which Mr. Stassano has "strong doubts," I think that most users of electric energy will agree with me that obtaining it at $8 a horse-power-year is not easy in this country. Most certainly it cannot be obtained at that rate, nor even at 50 per cent more than that rate, at Niagara Falls. There are other places where power can be obtained more cheaply than here, but then there are other considerations, such as freight charges, etc., which counterbalance this advantage.

NIAGARA FALLS, N. Y. FRANCIS A. J. FITZGERALD.

Schweitzer Celebration.

A commers was given on March 13, 1909, to Dr. Hugo Schweitzer, celebrating the fifteenth anniversary of his services as secretary of the New York section of the Society of Chemical Industry, the twentieth anniversary of his landing in America, the twenty-fifth anniversary of his doctorate, and the ninth anniversary of the organization of the Verein Deutscher Chemiker.

Some 300 chemists participated in the commers, which was held in the beautiful banquet hall of the Liederkranz Club of New York City.

Mr. Elwood Hendrick presided. Würzburger beer was served, and later in the evening a cold dinner.

As Dr. Schweitzer is known to every chemist in this country through his fifteen years' service as the American secretary of the Society of Chemical Industry, and through his long connection with the Farbenfabriken of Elberfeld Co., there is here no necessity of a long biography. But we quote the introductory notes by "R. C. S." from the commers program.

"Quod felix faustum fortunatum que sit—runs the benevolent greeting of the diploma which the German alma mater confers on her doctor-sons, exhorting them to hold aloft the banner of science, progress and humanity, to be warriors bold in behalf of her ideals and conquerors of new realms. Thus equipped, our hero lingered somewhat longer at various seats of learning, having already served his year with the horse-marines, to still further improve his mind and show frivolous youths how, and then sauntered forth into the world to wring the last saccharose crystal from phlegmatic treacle and to rival the shades of the rainbow. After a lustrum new yearnings rose to his breast, and tucking the aforementioned diploma and letter of credit, on credit, in his recticule, he shook the Fatherland's dust off his slippers, just as if he were the knockers one, held in low esteem by an exalted personage; and thus he came to our beloved country.

HUGO SCHWEITZER.

"One fine morning he walked down the gangplank with his hands in his pockets, to increase their receptivity, and Cæsar's famous dictum about the dice-box on his lips. In the sunny Southland he fondled once more saccharine juices and for a few months dabbled in plastics in the shadow of old Greylock. Then the metropolitan vortex drew him in, and near the lair of predatory wealth he dispensed chemistry, causing said wealth to change places. We just pause to note that at this time he began to taste connubial bliss, and in due season domestic symphonies reverberated through the house.

"Presently his trustful nature brought him into alliance with a bicontinental trust, in whose service he has slaved ever since, doing the grand circuit, growing in jollity, dignity and merit, old Pactolus leaving a copious sediment as of yore. With congresses and conferences, banquets and bureaux, his life has been like the busy bee's. Say, dear colleagues, are there any more like him? And now on with the commers! As Lauriger puts it: Nunc est bibendum, nunc pede libero pulsanda tellus."

There were salamanders and songs—Gaudeamus; a biographical song, "Hugo on an Autumn Day"; "My Country, 'Tis of Thee," "Deutschland, Deutschland uber Alles" and many others.

Prof. Chas. F. Chandler was the toastmaster, and was as jovial and eloquent as ever. He traced the career of Dr. Schweitzer since his graduation from the University of Freiburg, and referred particularly to a number of valuable discoveries by Dr. Schweitzer, such as that of azophenylene, the base of a series of important dyestuffs, as well as to his numerous papers on technical subjects in chemical journals. But apart from his scientific contributions Professor Chandler said that the American chemical profession owed much to Dr. Schweitzer for the conspicuous part he has taken in promoting a closer union among chemists and for his constant efforts in advancing the interests of the younger members of the profession. Professor Chandler concluded by saying that he had not only admired Dr. Schweitzer, but had learned to love him.

If possible, the personal note was even more emphasized in the felicitous speech by Mr. Thomas J. Parker, who presented to Dr. Schweitzer a silver tea service as a lasting souvenir of the occasion, with the injunction to "use it."

Dr. Schweitzer expressed his thanks in an impressive speech of great modesty, leading to a climax of beautiful sentiment. He said little could be accomplished by an individual. "For chemists it is indispensable to work together. It has been said success can only be obtained, if above all, science and technique support each other. If this be true—and I firmly believe in it—then the future of chemistry in our great country is brilliant indeed. For we have succeeded in creating a democracy of chemists, with the Chemists' Club as its center, where we associate so closely that the proper exchange of ideas becomes inevitable.

"Here the young graduate comes in contact with the teacher of our science who has made an international reputation for himself, and here the young beginner with the proud distinction of earning fifteen dollars per week meets on an equal social footing the millionaire captain of industry. All are ready to help and to assist by word and deeds, and all are ready to get as much pleasure and enjoyment out of such association as possible. There is no envy, no jealousy; on the contrary, there is general rejoicing at whatever any of us may accomplish. There does not exist such a union of kindred spirits in any other place in the world, and, like myself, you all consider an evening spent among our friends in the Chemists' Club the most delightful of all social functions.

"I wish and hope that it may ever be so, that we may ever be helpful to one another, and if need be to our families, eager to work, just as eager to play, friends of all good fellows, enemies of the dishonest fakirs and ignorant fanatics."

A few more impressive speeches were made. Mr. Seitz, as president of the Liederkranz Club, expressed his pleasure at having this celebration held in their club. It has always been the mission and the privilege of the Liederkranz, not only to advance musical art, but anything that tends to promote German-American co-operation in the active furtherance of culture and science.

Mr. I. J. R. Muurling, president of the Farbenfabriken of Elberfeld Co., while expressing his high appreciation of Dr. Schweitzer as a man and a scientist, was inclined to think that

of his incentive to his work to his better-half, who [illegible] proposed

[illegible]der Vet made some remarks in breezy fashion. The [illegible] States has always had practical men who knew how to [illegible] Germany has been the leader in producing men who also knew why. He expressed the hope that there would be an [illegible] in chemical education along the combined lines of how and why in this country.

[illegible] there were more songs, including the irrepressible Clemens[illegible]. There was an excellent, amusing, attractive, and suggestive vaudeville performance. To sum up, it may truly be said that it was one of the most enjoyable social gatherings of chemists ever held in this country—worthy of the "Democracy of American Chemists" and of the man who has done so much in building it up.

Corrosion of Zinc-Plated Iron Wire and Corrosion of Tubes and Shells of Steam Boilers.

In our Vol. VI, page 492, we gave a short abstract of a paper presented by Dr. W. H. Walker, of the Massachusetts Institute of Technology, before the American Electrochemical Society at its New York meeting last autumn. As the paper has now been printed in full in Vol. XIV of the *Transactions*, we supplement our former abstract by giving in full those portions of the paper which relate to two very interesting, practical problems; one is the protection which a zinc coating gives to an iron surface, with special reference to the corrosion of barbed wire fencing.

Although the protection which a zinc coating gives to an iron surface is universally mentioned in text-books, the fact that, in consequence of the protecting action to the iron the zinc itself will rapidly be dissolved is not mentioned. Both actions will be the more complete the more energetic is the solution of the zinc and the correspondingly greater flow of current from the zinc to the iron (the zinc and the iron forming a short-circuited galvanic couple).

But the flow of current will depend, among other things, upon the resistance offered to its passage through the water. Hence it should be possible to get water so pure, or to place the iron so far from the zinc that the electromotive force of the system could not overcome the resistance, and no appreciable current would flow, and the iron should corrode as though no zinc were attached to it.

It was found that Boston water as drawn from a tap in the laboratory had a sufficiently low conductivity, so that zinc attached to a piece of sheet steel would protect it when placed in this water for only a distance of three-fourths of an inch. When a little common salt was added to the water the protection was extended for a foot and one-half or more. Hence, in order that zinc may protect iron from corrosion, it is necessary to have present in the water surrounding the two enough electrolyte to insure a low resistance to the flow of the current generated by the solution of the zinc.

The fact that the presence of a metallic iron surface accelerates the corrosion of zinc has an important bearing upon the protection of such structures as **barbed wire fencing**, or wherever both an iron and zinc surface are exposed. In making barbed wire fencing the wire is first galvanized and then wound [illegible] the cross-wires forming the barbs being cut at an angle in order to make a pointed barb. This freshly cut surface of iron is thus exposed and so furnishes just the surface required for depolarizing the zinc surface and thus greatly increasing the rapidity with which the zinc coating will corrode. As the zinc coating thus recedes from the iron surface, the [illegible] on account of the low conductivity of the water [illegible], and this is the explanation of why deterioration of a barbed wire fence always starts at the barbs and travels [illegible] there along the strands.

It would seem worth while in this connection to pass the finished barbed wire through a wet galvanizing bath in which the wire should be cathode and be surrounded by a zinc anode, so that the current would be attracted to the barbs, and hence the zinc deposited almost exclusively on just the points where it is needed. Little if any would be plated on the wire strands.

In examining barbed wire fencing which has been exposed for two or three years, it is not infrequently found that one of the two main unit wires making up a strand will have corroded much faster than the other which is close alongside of it and in direct contact with it. Three factors may enter into this difference. First, the steel may itself be inferior in one wire; second, the zinc coating may be thinner, i.e., "wiped" closer on one than on the other; and, third, the zinc coating may be contaminated with a zinc-iron alloy. While the first two are matters understood by the wire makers, the third is not so easily detected.

The alloy known as "hard dross" by the galvanizers, and which, owing to its high melting point, settles to the bottom of the galvanizing pot, contains from 4 to 6 per cent. of iron. This is in reality a mixture of the alloy *Zn*, *Fe* and zinc, and, while the properties of zinc still predominate, the effect of the presence of the alloy may be easily detected.

Contrary to what might be expected, the iron zinc alloy *Zn*, *Fe* is electronegative to iron; that is, it will act like platinum or mill scale and accelerate the depolarization of the cathode (hydrogen) surface, and thus aid corrosion.

The second practical problem discussed by Dr. Walker at some length is the **corrosion of tubes and shells of steam boilers.** The function of the oxygen (with which the normal feed water of a boiler is saturated) is here the same as in other types of corrosion, and, as boiler tubes cannot be protected by paints or other coatings, the detrimental effect of the oxygen must be counteracted in some other ways.

If the feed used be perfectly free from dissolved salts there is lacking in the boiler that protective coating of scale which, while it reduces the heating efficiency of the boiler, also protects the iron of the boiler from the access of oxygen. In such a case it is well to feed into the boiler, when first put into commission, enough water containing scale-forming salts to thoroughly coat the shell and tubes with a layer of hard boiler scale. This practice is very common in marine boilers which are to be fed with distilled water.

Although the presence of alkalies inhibits the corrosion of iron by reducing the hydrogen concentration, and although, as Dr. A. S. Cushman has shown, the presence of bichromates in solution greatly inhibits this action, the best practice is to remove oxygen from the feed water before it is introduced into the boiler, just as it is best practice to remove the scale forming salts of the ordinary feed water before this is used.

As the solubility of oxygen in water rapidly decreases with rise in temperature, by far the larger portion of the oxygen dissolved in natural waters, or in distilled water, is removed by heating the water to near its boiling point. If, in addition to the application of heat, a vacuum be maintained over the water the dissolved oxygen is practically all removed, and such feed water will never corrode the boiler. Such an arrangement has been in use in a few of our largest steam generating plants with the greatest success.

Even if no diminished pressure can be maintained over the hot feed water, the mere heating to the boiling point will drive out most of the dissolved oxygen. If, therefore, an open feed-water heater be employed, the feed water is deprived of its oxygen without additional expense for the heat, because the feed water in any case must be brought to its boiling point the moment it gets within the boiler. This method of treating boiler feed water has also been found very efficient in the power stations of some of our large electric railway companies.

A third method of depriving the feed water of its oxygen is to carry the same through a tank filled with small pieces of scrap iron. The accumulated iron hydroxide must, of course,

be cleaned out of the tank periodically and the scrap iron renewed. But from the point of economy it is, of course, much cheaper to pit and corrode scrap iron in a tank than it is to corrode the tubes inside the boiler, so that this method, especially if combined with an open feed-water pre-heater, is in the end a very economical and highly efficient one.

If, for any reason, it is not possible to remove the oxygen from the water, before it is fed into the boiler, numberless boiler compounds are proposed to counteract the effect of the oxygen within the boiler. Such a method is, of course, irrational and is nothing more than voluntarily taking poison, with the expectation and intention of taking at the same time an antidote therefor. The compounds and mixtures which have been proposed for introduction into a boiler include practically every thinkable material extant.

The basis of most of them, however, is sodium carbonate in the form of soda ash, and are effective only insofar as they reduce the hydrogen concentration in the water. A considerable portion of the soda added is frequently consumed in precipitating the scale forming salts of the water, and is as a rule of low efficiency as an anti-corroding ingredient. Inasmuch as an alkaline solution of the ordinary tannins or tannin extracts breaks up more or less when subjected to the heat and pressure of a steam boiler into gallic and pyrogallic acids, which are energetic absorbents of oxygen, a solution of this material is efficient as a boiler compound for preventing corrosion.

A very old method is, of course, the introduction of pieces of metallic zinc into the boiler, which operate in accordance with well-known principles. It is necessary, however, to maintain good electrical contact with the iron and to have in the water sufficient electrolyte of some sort to carry the current from the zinc to the iron. For the protection of condenser jackets using sea water this method has been found to be perfectly satisfactory and entirely trustworthy.

Autogenous Welding of Aluminium.

By M. U. Schoop.

Autogenous welding of metals has been developed into a thoroughly practical method for metal workers, especially since the gases required for the welding flame (hydrogen, oxygen, acetylene) have been placed on the market in compressed form and at a reasonably low price. For, as a matter of fact, there are very few metal-workers' shops now in existence which manufacture the required gases themselves.

The prototype of the modern autogenous welding process is the lead-burning process in which the joints are made without the aid of a special solder containing a foreign metal. As to terminology, one should speak of autogenous welding, not soldering, since the characteristic feature of soldering is the use of a solder of a foreign metal with low melting point.

While a number of metals, like lead, steel, also copper, can be welded autogenously without any difficulty, if only the flame temperature is sufficiently high, considerable difficulties are experienced with other metals, like nickel, silver and aluminium. In the case of copper, if thick copper sheets are to be welded, quite considerable experience is necessary in order to avoid brittle joints.

The existing patent literature shows that a great many inventors have been interested in the problem of soldering or welding aluminium. By far most of these experiments or suggestions have not been introduced into practice,[1] as they intended to accomplish something that is apparently impossible, namely, to make *durable* joints with the aid of foreign metals. In my collection of patents, which is by no means complete, I have some 50 patents for soldering aluminium and aluminium alloys.

The question why it is so difficult to weld aluminium autogenously, in spite of the relatively low melting point (about 660° C.), can best be answered by a little experiment. If four or five thin aluminium wires are twisted together and the free end of the bundle is held into a strong Bunsen flame, the wire ends do not weld together, but remain separate, being covered with a white and hardly perceptible oxide film.

Aluminium surfaces tend to become covered with a thin oxide film, even at ordinary temperatures, and this is the reason why, if one tries to weld two surfaces, the fluid metal portions will not unite.

The problem of aluminium welding is, therefore, to remove this very thin and tough oxide film by some chemical or mechanical means. For example, the oxide film can be ruptured by means of a suitable instrument, so that the pure fluid metal portions can then unite. But this rather rudimentary method

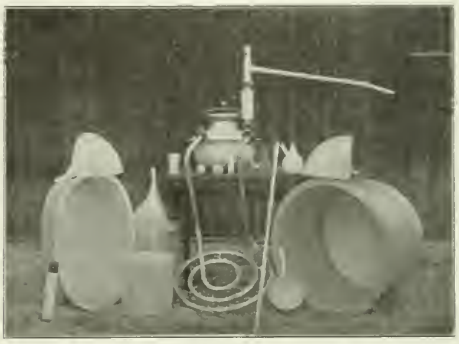

FIG. 1.—AUTOGENOUS WELDING OF ALUMINIUM.

can be used only in a few cases of practice, namely, when strong solid metallic pieces are to be welded. With thin sheets or wires this method would surely be unsuccessful, even if the operator were highly skilled.

The elimination of the oxide film by chemical means is, therefore, the only method to be considered. In other words, the object is to provide a pure metallic aluminium surface during the felding process. If the surfaces to be joined are cleaned so as to be pure aluminium, they will satisfactorily weld together.

The question is, therefore, which substances are suitable as fluxes for dissolving the aluminium oxide and which other properties are required of such a flux. In the first place, we might consider the use of some agent, which simply excludes the air, like glass powder or borax, or the use of a very hot flame which might reduce the oxide without any reducing agent. But experiments along these lines will soon show that success cannot be obtained in this way and that the use of a reagent which dissolves the oxide cannot be avoided.

Other requirements besides the solvent action on the oxide are the following: The melting point should be near that of aluminium. The evaporating point should be as high as possible, i. e., the flux must be stable under the influence of the flame. When fluid, the substance must spread over the hot aluminium surface as a thin enamel-like layer, cutting off any access of air to the surface. Finally, the substance must be free from oxygen and must not have any tendency of combining with aluminium.

Only a flux which fulfills all the above requirements, renders autogenous welding of aluminium possible in such a way that the welded metal differs neither chemically nor physically from normal unwelded metal. For my first experiments, which I made as early as 1900,[2] I used potassium bisulphate, $KHSO_4$, which is stated in chemical handbooks to be well suited for dissolving materials which are soluble only with difficulty, like

[1] An exception is the welding process of Heraeus in Hanau (German patent 118,868 of 1900 and Zusatzpatent). This process has been in use on a commercial scale for a number of years.

[2] Chemiker Zeitung, 1907, No. 6[illegible] M. U. Schoop on the autogenous welding of aluminium.

As the melting point (300°) is too low, [illegible] of some potassium sulphate, K_2SO_4, [illegible]

This mixture did not prove sufficiently effective in [illegible] by dissolving the oxide so that the results were first [illegible] satisfactory. The potassium bisulphate gives off water and sulphur trioxide under the action of the flame and changes thereby into potassium pyrosulphate. These potassium salts have the good property that they do not decompose at high temperatures when molten they form an easily fluid, protective layer on the aluminium surface.

I then tried a great many substances with a pronounced etching effect on aluminium, like potassium hydroxide, hydrochloric acid, chlorates, etc. But a really satisfactory solution of the problem was obtained only by the use of alkali chlorides. In working out the process, I had the great advantage that I knew thoroughly all the tricks of lead welding and was also intimately acquainted with the oxy-hydrogen flame.

As to the reactions which really occur in welding aluminium with an oxy-hydrogen flame and a flux, it seems that the matter is not as simple as might be thought from the above considerations. It rather seems that there is not only a chemical deoxidation of the metallic surface, but also a physical process similar to the solution of sugar in water. It is certain that [illegible] compounds are formed which evaporate and that the oxide film is removed in this way.

It is simpler to *solder* aluminium, as this is always successful if only the metallic surface is kept clean during the soldering process. If this condition is fulfilled, aluminium is really one of those metals which can be easily soldered with ordinary soft solder. But it is also well known that the original strength and quality of the joint thus obtained are lost slowly, but surely, especially in presence of water or moisture.

Although aluminium forms a series of alloys of technical importance, it is a rather sensitive and disagreeable metal, if in contact with another metal and with water.

In the galvanic series it is the first metal on the positive side, and has a remarkable tendency to electrolytic local action in the presence of foreign metals, with water decomposition and formation of hydroxide.

Masséna once recommended to the French army department an aluminium alloy with 3 per cent copper for bottles for the soldiers going to Madagascar. The reason of his recommendation was that the material becomes thereby much harder and tougher mechanically. This unfortunate experiment cost hundreds of thousands of francs; for after three or four months the bottles disintegrated completely and this experience has discredited aluminium (in spite of its unsurpassed hygienic and physiological qualities) to such an extent in France that up to the present day it has been found very difficult to bring aluminium into popular favor in France as a cooking and kitchen metal.

To test the quality of a metallic weld, several methods may be used. Comparative tensile tests may be made of the pure metal and the weld. Or an investigation may be made whether the joint becomes the seat of e.m.fs. under certain experimental conditions, or whether thermoelectric currents are set up on heating. Further, a section may be made through the joint, polished carefully and etched, and then studied with the microscope. The latter method is especially suitable in the present case, as it is very sensitive and yields quick results which can be preserved photographically.

About three years ago the Conservatoire National des Arts et Métiers, in Paris, made for me a microphotographic investigation of welded aluminium sheets. It was found that the metal in the joint differed from the normal metal elsewhere only in that the structure in the joint was coarser and more crystalline.

There is nothing surprising about this, as the sheets are [illegible] aluminium, while the joints and their surroundings are [illegible] heated to a temperature at which the metal becomes soft. Tensile tests are absolutely unobjectionable test, the sheets to be welded should be tempered first by heating to 350° or 400° C. and then the whole welded piece would have to be rolled. If two welded and non-tempered sheets are etched, for instance, with dilute hydrofluoric acid, the following observation is made: The attack of the acid is more manifest at the joint than elsewhere, and if the etching process is continued long enough, dentrites (with a direction perpendicular to the joint) appear of especially characteristic form. On the other hand, unwelded portions have not any evident typical metallic structure, even if the etching operation is continued for a long time. Evidently the original crystalline structure has been annihilated by the rolling process so that it is no longer visible.

It is similar with most of the other metals which can be rolled, like lead, tin, copper.[3] But it is clear that it is easy to

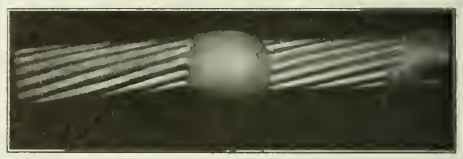

FIG. 2.—WELDED ALUMINIUM CABLE.

impart to the joint the normal strength and tenacity by mechanical treatment afterward, since aluminium can be hammered, rolled, etc., at will, just like copper. According to my experience, quenching in cold water has no appreciable effect on the joint, but for the quality and durability of the joint it is important that the aluminium be as pure as possible.

Welded aluminium wires were also tested as to electric conductivity. These experiments were made by Prof. J. Sahulka, of Vienna. He found that the reduction of conductivity was practically negligible. A wire of 3 m length and 4 mm diameters would increase about 0.006 per cent in resistance on account of one joint. According to Professor Sahulka "the results indicate that no foreign metal is present in the joint, or, in other words, that the pieces are welded together, not soldered together."

By means of mechanical tests, Professor Kirsch, in Vienna, found that aluminium strips welded together by my process have the same tensile strength as non-welded strips. Wires welded together by the same process have the same torsion strength as non-welded wires. "The results of the mechanical tests indicate that there is no foreign metal in the joint, or, in other words, that we have to do with a welding, not a soldering, of the aluminium pieces."

I would like to refer briefly to aluminium as a substitute for copper for electrical conductors. As it has been the leading country in the case of electric traction, the United States has become the pioneer in the use of aluminium for transmission lines. In the United States aluminium conductors have already been used on a large scale at a time when the price of aluminium was still three or four times the present price, and the results obtained with aluminium lines in the United States have been quite satisfactory.

It can be easily seen that not only the cost of the metal itself is much less, but that there is also a saving in weight and freight. For instance, let us consider two lines, both of 1000 m length and of the same conductance. The copper line has a section of 1 sq. cm and therefore weighs 89 kg. If aluminium has a conductivity of 65 per cent in comparison with copper (100 per cent), the equivalent aluminium line has a cross-section of 1.65 sq. cm. and weighs 42.85 kg.[4]

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[3] See also the highly interesting paper by Wm. Campbell: Das Gefüge der Metalle (Halle: Knapp).

[4] The comparative constants are:

	Aluminium.	Copper.
Specific weight, rolled	2.6	8.9
Melting point	665° C.	10,846
Hardness, hammered	4-5	3-5
Tensile strength, rolled	25 to 27 kg per sq. mm.	
Linear elongation	0.0423	

If for the sake of simplicity we now assume the price of copper and aluminium to be equal, namely, 2 francs (40 cents) per kilogram, then we have for the aluminium line a saving of 53 per cent in first cost of metal and a saving of 48 per cent in weight. In reality the conditions are even more favorable to aluminium, since any quantity of aluminium ingots can now be bought in Europe at 1.20 francs per kilogram (about 10 cents per pound).

Aluminium wires and cables are now joined by means of mechanical and more or less primitive couplings, and a certain loss of voltage at the joint is unavoidable. This has, naturally, a bad effect on long lines. It is different with welded lines, where there is practically no increase in resistance. Further, the welded joint cannot decompose, since there are no foreign metals present, and the joint can be made with the simplest means (gasoline soldering lamp and reduction paste) wherever required.

Fig. 1 shows a number of articles of aluminium welded by my method. Fig. 2 shows a welded aluminium cable. A second article will follow.

Garenne-Colombes, near Paris, France.

Reduction of Iron Ore in the Electric Furnace.

Mr Remo Catani, engineer of the Société Elba, at Porto Ferraio, Elba, Italy, has recently made an interesting investigation of the possibilities of the electric furnace for iron-ore reduction in comparison with the blast furnace. From an abstract by Professor Neumann of Mr. Catani's paper in *Stahl und Eisen*, Feb. 24, we have prepared the following summary:

In the blast furnace it is theoretically possible to obtain the following temperatures:

1350° C. with moist cold blast.
1650° C. with dry cold blast.
1900 C. with moist blast of 700°.
2200° C. with dry hot blast.

In the electric furnace it is easy to produce much higher temperatures.

Compared with the daily output of a modern blast furnace, the capacity of an electric iron-reduction furnace is very low. But the matter appears in a different light if we consider the capacity for the same energy consumption. J. W. Richards in figuring out the reduction of magnetite ore with charcoal (assuming 30 per cent heat loss by radiation, also a complete loss of the latent heat of the gases which escape at 300° C., etc., see our Vol V, page 165) finds that the reduction of 1 metric of pig iron requires 112-kw-days, or 1 hp-day yields 6.5 kg of pig iron. If an electric furnace gives 8 kg of pig iron per hp-day, this must be considered quite a good result under present conditions. Heroult claims that with a 10,000-hp plant he can get 12 kg per hp-day, but this possibility must still be proven in actual practice in continuous operation. An electric furnace plant of the same capacity as a 200-ton blast furnace would therefore require 25,000 hp.

The main difference between iron ore reduction in the blast furnace and in the electric furnace is that the reducing agent is primarily carbon monoxide in the blast furnace and solid carbon in the electric furnace.

In the blast-furnace gases the ratio of carbon monoxide to carbon dioxide varies between 1.56 and 3.22, but in the average = 2. The higher this ratio the greater the fuel consumption. If we assume the reaction to be $Fe_2O_3 + 9\,CO = 3\,CO_2 + 6\,CO + 2\,Fe$, then a production of 1000 kg of iron requires a consumption of 964 kg of carbon.

If we assume with Bell that iron oxide loses in the higher zones 25 per cent of its oxygen, we arrive at the following formula:

$$Fe_2O_3 + 3.4\,C + 6\,CO = 1.8.4\,CO + 0.4\,CO + 2\,Fe$$

This gives a consumption of 723 kg of carbon.

The greater the extent of direct reduction by means of carbon the less the consumption of carbon. In cases in which ferric oxide is first reduced to ferrous oxide, the following equation is obtained:

$$Fe_2O_3 + 2\,C + CO = CO_2 + 2\,CO + 2\,Fe.$$

with a consumption of only 321.4 kg of carbon.

For the smelting process in the electric furnace the reduction may be assumed to be completely direct. In reality carbon monoxide will be formed, but will act as reducing agent in the cooler zones, as in the first of the above formulas, and the ratio of CO to CO_2 will be larger than otherwise, say, = 3. Taking the smaller lime addition in the electric furnace into consideration, Catani arrives at the formula

$$16\,Fe_2O_3 + 39\,C = 9\,CO_2 + 30\,CO + 32\,Fe.$$

This gives a theoretical consumption of 261 kg carbon per 1000 kg of iron.

In the experiments at Sault Ste. Marie under supervision of the Canadian Government up to 308 kg were consumed. The reduced pig iron contained 4.6 per cent C and 94.3 per cent Fe.

Catani calculates an example of iron ore reduction for the two cases of the blast furnace and the electric furnace. The consumption of ore is the same in both cases. The consumption of lime is less in the electric furnace, on account of the smaller amount of carbon in the carbon. The electrode consumption ($40 per ton) is figured as coke by Catani, but on account of the higher price he figures on 80 kg coke instead of 8.17 kg of electrodes.

The composition of the raw materials is as follows:

Ore: 70 per cent Fe_2O_3, 10 SiO_2, 0.2 Mn_3O_4, 0.7 P_2O_5, 0.2 SO_3, 3.0 Al_2O_3, 4.0 CaO, 2.0 MgO, 10.0 H_2O.

Coke: 85 per cent C, 10 ash, 2 volatile material, 10 moisture (?).

Lime: 95 per cent $CaCO_3$, 5 per cent impurities.

Blast: 1 per cent moisture (about 50 kg per 1000 kg iron).

Electrodes: 95.78 per cent C, 2.02 volatile substances, 2.20 ash.

The white pig iron to be produced shall contain 94 per cent Fe and 1 per cent Si. To produce 1000 kg of iron (containing 94 per cent Fe) 1920 kg ore are required. Since, together with the iron, other elements which are present are also reduced, the pig iron produced has this composition: 94 per cent Fe, 1 Si, 4 C, 0.57 P, 0.15 S, 0.23 Mn.

In the *blast furnace* the coke consumption is 1113 kg. There are required for reduction 964 × 0.94 = 906 kg, for the desired carbon content in the pig iron 40 kg, or together 946 kg carbon, equivalent to 946 ÷ 0.85 = 1113 kg coke. The average coke consumption is, according to Junge, 1180 kg in American blast furnaces and 1127 kg in German furnaces.

To burn this coke a blast of 3047.4 kg of dry air is required, equivalent to 4097.4 kg of air with 1 per cent moisture. The lime addition is assumed to be 500 kg.

To produce 1000 kg of iron in the *electric furnace* 1020 kg of ore are required, and for this reduction 335 kg of coke. Since 70 per cent of the lime is required for slagging the impurities in the ore, 30 per cent for the coke impurities, there are required

$$0.7 \times 500 = 0.3 \times 500 \times 335 \div 1113 = 395 \text{ kg lime}$$

Table I shows the quantity and composition of the gases in the blast furnace and in the electric furnace.

TABLE I

	Weight per cbm kg	Blast furnace: Weight kg	Volume in per cent	Composition: Moist	Dry	Electric furnace: Weight kg	Volume cbm	Composition in per cent: Moist	Dry
CO	1.20	1408	21.1	22.37		492	393	15	61
H_2	0.09	7.9	4.8	4.4		3	33.9	4	6.1
CH_4	0.7	13	1.2	1.1		3	4	0.1	0.7
N_2	1.26	3805.7	57.1	57.8	60.83		..	..	..
CO_2	1.98	1317.5	16.5	13.4	14.1	30	83.3	2.1	29.9
H_2O	.8	225.4	2.8	1.2		2.8	49.4	2.8	..
Total		6785.1	83.5	100	100	63.1	866.2	100	100

Weight of 1 cbm moist gas 1.28 kg 1.28 kg respectively

The calorific value for 1 cubic meter of gas is also calculated by Catani, and from his figures he calculates for both processes what surplus of power is obtainable from the "waste" gases, above the power required for the furnace plant itself. The surplus of power found by him is 1151 hp and 451 hp, respectively per 1000 kg of iron per hour.

[illegible] for the blast furnace does not agree well with older figures, and Neumann has therefore revised the calculation and finds 780 hp-hours for the blast furnace and 380 hp-hours for the electric furnace per 1000 kg of iron. The figure for the blast furnace agrees with older figures from practice: Greiner, 800 hp-hours; Uehling, 858; Thomsen, 868 (see this Journal, Vol. III, p. 103).

The blast furnace requires $1113 - 335 = 778$ kg more coke than the electric furnace, or if, as stated above, the electrode consumption is figured as 78 kg coke, the blast furnace requires 700 kg more coke than the electric furnace for the production of 1000 kg of pig iron.

The comparison leads therefore to the following chief results:

In favor of the electric furnace: It requires 700 kg less coke than the blast furnace for the production of 1000 kg of pig iron.

Against the electric furnace: It requires electrical energy for heating the charge (which is not required at all in the blast furnace); moreover, the surplus power available from the waste gases is less with the electric furnace than with the blast furnace. The difference in the surplus power from the blast furnace and the electric furnace gases per 1000 kg of pig iron is 700 hp if we take Catani's figure and 400 hp if we assume Neumann's revised figure.

It is peculiar that, having revised this figure, Neumann continues to use Catani's figure in the further calculations. In the following we will give the calculations for both figures.

The above considerations permit us to state at once under which conditions the electric furnace can compete with the blast furnace. For this purpose we figure the above comparative advantages of the electric and the blast furnace in dollars and cents per 1000 kg of iron produced.

The 700 kg of coke, which are less required with the electric furnace than with the blast furnace, cost $0.7\,y$, if y is the cost of 1 ton blast furnace coke.*

The electrical energy required for heating the charge in the electric furnace for the production of 1000 kg iron is $1000 \times 24 \div n$ hp.-hours, if n is the number of kilograms of iron produced by 24 hp-hours. To this must be added 700 (Catani) or 400 (Neumann) hp-hours (which are less available from the electric-furnace gases than for the blast-furnace gases). If now the cost of the hp-year is x and the number of working hours in 360 days is 8640, the total cost of electric energy which is to be charged against the electric furnace in comparison with the blast furnace is:

$$\left(\frac{1{,}000 \times 24}{n} + 700\right)\frac{x}{8{,}640}$$

if we take Catani's figure 700, or

$$\left(\frac{1{,}000 \times 24}{n} + 400\right)\frac{x}{8{,}640}$$

if we take Neumann's figure.

By putting the saving in coke against the expense of electrical energy, we get the conditions under which the electric furnace and the blast furnace are just commercially equivalent:

$$(1) \quad y = x\left(\frac{4}{n} - 0.12\right)$$

if we accept Catani's figure of power surplus from gases, and

$$(2) \quad y = x\left(\frac{4}{n} - 0.07\right)$$

if we accept Neumann's corrected figure.

From these formulas we get the following two tables, giving the maximum price of electrical energy x, for which competition with the blast furnace becomes possible. It will be seen that the considerable difference in the surplus power figures of Catani and Neumann does not lead to very different results in the values of x.

From Equation (1) (Catani's surplus power figure), we get this table: Coke cost is y.

	y = Price of coke		
n	y = $4.00	$6.00	$8.00
6 kg	x = 5.12	7.67	10.25
8 kg	6.40	9.60	12.80
10 kg	8.00	12.00	16.00
12 kg	9.00	13.50	18.00

From Equation (2) (Neumann's surplus power figure), we get the next table:

	y = Price of coke		
n	y = $4.00	$6.00	$8.00
6 kg	x = 5.40	8.10	10.80
8 kg	7.00	10.50	14.00
10 kg	8.50	12.75	17.00
12 kg	10.00	15.00	20.00

A consideration of the capital investment is instructive. For a daily output of 400 tons of pig iron $n = 8$ (which, under present conditions, represents pretty good electric-furnace practice), there are required 50,000 or 55,000 hp in the power house, or 70,000 hp with reserves. If the cost of the plant is figured at $40 per hp, this gives a first cost of $2,800,000.

Finally the balance sheet of the materials involved in the process, as calculated by Catani for producing 1000 kg pig iron will be given:

Raw Materials.	Blast Furnace.	Electric Furnace.
Ore	1,920 kg	1,920 kg
Blast	4,097 "	...
Lime	500 "	395 "
Coke	1,113 "	335 "
Electrodes	....	20 "
Totals	8,530 kg	2,670 kg
Products.		
Pig iron	1,000 kg	1,000 kg
Slag	745 "	606.5 "
Gas	6,799 "	1,063.5 "
Totals	8,533 kg	2,670 kg
Calorific value of gas..	4,121,000 cal.	1,333,000 cal.

Density and Coherence of Electrolytic Deposits.

That the density and coherence of an electrolytic deposit can be greatly improved by the addition of a very small quantity of an "addition-agent" like glue, to the electroyte, has been known since Betts successfully employed this trick in his lead refining process. R. P. Jarvis and E. F. Kern (*School of Mines Quarterly*, Vol. 30, No. 2) have studied in detail the effect of the presence of certain "addition-agents" upon the density and the coherence of electrolytically deposited copper, lead and silver.

They find that fluo-silicate electrolytes of lead, copper and silver give more coherent deposits than those formed in the nitrate electrolytes of lead or silver, or in the sulphate or chloride electrolytes of copper.

The lead deposit is improved by the addition of 1 part tannin to 200 parts of an almost neutral electrolyte of lead nitrate, or 1 part to 5000 parts of a lead fluo-silicate electrolyte.

The copper deposit is improved by the addition of tannin to copper sulphate or copper fluo-silicate electrolytes. With a cuprous chloride electrolyte tannin has no effect.

Silver deposits from silver nitrate or silver fluo-silicate solutions are improved by the addition of 1 part of gelatine to 10,000 to 14,000 parts of solution.

Dr. Kern will present a paper on this subject before the American Electrochemical Society. This will be reported in full in this journal.

* In a manner of fact, this is really an understatement of the case of the electric furnace, since the fuel required as reducing agent must be good coke in the blast furnace, and may be charcoal or cheap peat coke in the electric furnace. Although the weight in both cases is the same, there may be a difference in price and this should be added to the above figure.—Ed.

The Production of Pig Iron at the Electric Furnace and the Industrial Utilization of Pyrite Residue.

By F. E. Carcano.

With reference to the notable article of Mr. H. Harden and the editorial note on this subject, which appeared in the January number of this journal, I offer the following considerations:

Admitting as indisputable the principle that at the present time the electric furnace cannot generally compete with the blast furnace in the production of pig iron, I desire to demonstrate a particular though interesting case in which the electric furnace can well hold its own against the blast furnace.

In Italy the acid industry is well developed. This industry abandons as a residue almost from two to three hundred thousand tons yearly of pyrite ash, and this refuse, accumulated in many years, is actually available.

These residues of pyrite contain from 46 per cent to 57 per cent of metallic iron, with about 2 per cent of sulphur. The refuse is generally silicious, but in some cases the matrix contains considerable lime.

There are, therefore, about 100,000 tons of iron yearly unutilized, quite a considerable quantity, especially in Italy, where iron ores are scarce and practically found only in one locality (on the island of Elba).

The abandonment of such an important stock till the present time can only be explained by two reasons. Technically it may have appeared doubtful whether a material so rich in sulphur and in such a powdered form could be treated with good results in the blast furnace. There is no mine of good iron ore near these deposits with which the refuse could have been mixed, as is done in other European countries. Further, these deposits are nearly all found in the interior, far from the places where coke (which comes from abroad) is cheap enough to render iron production economical.

But close to these refuse heaps water power is available under good conditions. Naturally, the opportunity for the electric furnace appeared good. Certainly I do not believe to be the only one to have studied the utilization of such refuse by means of the electric furnace; but having been able to apply my electric furnace and my process, thanks to the help received from the "Società Unione Italiana Concimi," in experiments which lasted many months, and with furnaces of 400 hp, I think it will be of interest to give some results and to discuss the matter especially from the economic point of view.

In the locality where the experiments were carried out (in Lombardy) the kw-hour costs about 0.009 franc (0.18 cent). Hard coke as generally used in blast furnaces costs in the Italian ports 45 francs ($9) per ton, or would cost in the above-named locality 50 francs ($10) per ton. But our experiments have shown that we could use in our electric furnaces small coke and coal dust, which can be had in large quantities and at such low prices as 12 and 20 francs ($2.40 and $4) per ton.

As for the pyrite ash we will give them a conventional price, delivered at the furnace, of 5 francs ($1) per ton. I say a conventional price, since in reality even to-day in many places this residue can be obtained free of charge.

As to the means used to utilize the iron contained in the refuse, I will mention two types of furnaces which were alternatively used:

A. First, a furnace with two groups of electrodes connected in series, with a carbon hearth and lining of magnesia and with free escape of gas and flame.

B. Second, an arc furnace with a vaulted roof, of special material, very low and completely closed, so as to permit complete recovery of the gases.

The first type of furnace was much easier for experiments, but for a permanent application the second type is more economical. While the life of the vaulted roof is much longer than in analogous designs and while the energy consumption is equal to that in a furnace of the first type, we have the advantage of a smaller waste of the electrodes and we are able to recover all the evolved gases.

To obtain good pig iron from a material so rich in sulphur, both types of furnaces we found to be of good service.

What is essential and somewhat difficult is to find the correct mixture of fluxes for each sort of pyrite.

It is wrong to hold that the high temperature of the electric furnace is sufficient to obtain a satisfactory desulphurization. A pig iron obtained from a mineral containing 2 per cent of sulphur will rarely contain less than 0.4 per cent of sulphur if treated with fluxes calculated by ordinary methods, unless the operation is very much extended, which evidently means a waste in energy. Nor is it sufficient to add a great quantity of lime, as it would again require a rather inconveniently great amount of energy to maintain it in the fluid state. Therefore it is necessary to make a slag with multiple bases, the components and proportions of which must be studied for each type of mineral to be treated.

In this manner it is possible to obtain pig iron of such composition as will be discussed later, with a cost of fluxes of 3 to 4 francs (60 to 80 cents) per ton of pig iron.

The amount of energy required, as has been shown in many experiments, is, in the average, 2200 kw hours per ton of pig iron, or 3.8 tons per kw-year of 350 working days. This figure is practically the same as has been obtained in other experiments with the usual iron ore.

As to the consumption of the electrodes, with the furnace of type A it amounted to 20 to 24 kilograms per ton of pig iron, costing about 7 francs ($1.40), but with the furnace type B this cost is reduced to almost one-half.

The cost of labor, maintenance, etc., of plants of medium size comes very close to the figures of the Canadian Commission, namely, the cost of labor about 5.50 francs ($1.10) per ton of pig iron, and the cost of maintenance about 4.50 francs (90 cents). This naturally refers to plants of 20,000 tons a year.

To sum up, the cost per ton of pig iron in the electric furnace under the above-mentioned conditions would be with a furnace of type A:

	Francs.
Mineral (pyrite ashes, 2000 kg)	10
Small coke and dust, 450 kg.	9
Divers fluxes and added material	4
Electrodes, 22 kg.	7
Maintenance	4.50
Labor	5.50
Electrical energy (2200 kw-hour)	19.80
Total	50.80
Or	$11.96

With a furnace of type B it is possible to reduce this sum by two or three francs in the cost of the electrodes.

In the same locality and with the same original material, what would be the cost of making pig iron at the blast furnace?

	Francs.
Mineral (pyrite ashes, 2000 kg)	10
Hard coke, 980 kg.	49
Divers fluxes	4
Labor	4
Compressed air	1.50
Maintenance	4
Total	72.50
Or	$14.50

As will be seen, the balance is directly in favor of the electric furnace. But we do not need to insist on this point alone. It may be emphasized that pig iron of extra good quality was obtained, as our experiments have demonstrated, *without any preliminary preparation of the raw material.* With the blast

[illegible] a certain preparation, the cost [illegible] at least 3 francs per ton of mineral [illegible] per ton of pig iron.

To give an idea of the economical situation, I will mention that [illegible] quality costs at the Italian ports 80 to 82 francs ($16 to $16.40), and 6 to 7 francs ($1.20 to $1.40) [illegible] the interior.

As to the possibility of the blast furnace to utilize the gases which are evolved as a source of power, I wish to emphasize that this is of small importance in a country where energy costs so little as mentioned above.

Nevertheless, it has been seen that in electric furnaces of type B the evolved gas can perfectly well be recovered, and our studies are now actually directed toward the utilization of this gas, not as a source of energy, but as a reducing agent and for preheating the material, permitting thus to obtain an economy of coal and energy which I estimate to be about 5 to 6 francs ($1 to $1.20) net.

Let us now examine the kind of pig iron obtained and the applications to which it can be put.

Pig Iron for the Foundry.

In a series of experiments pig iron of the following composition was obtained. It is well adapted for the foundry:

S.	Ph.	Mn	Si.
0.046	0.003	2.23	3.83
0.058	0.075	2.17	4.46
0.030	. .	3.20	1.72

We have also made a long series of experiments to solve the problem of utilizing this pig iron directly—that is, using the pig iron as it comes out of the electric furnace to make castings (especially tubes, pillars, ornaments, etc.), and with special modifications of the construction of the furnace even this result was obtained.

Pig Iron for Steel.

Another series of experiments gave us pig irons of the following types:

S	Ph.	Mn	Si
0.031	0.070	1.054	5.68
0.015	0.073	2.26	6.70
0.026	0.016	2.54	5.70

Pig iron of this kind would be perfect for acid open-hearth and Bessemer plants. But it would be wrong to produce such pig iron in electric furnaces and then to remelt it.

In the locality where we are working at the present time, where the energy is cheap, it would be advisable to charge such pig iron, while still in its fluid state, into a second electric furnace to be converted into electric steel of high value.

With respect to other firms, which produce electric steel, an advantage would be gained in saving the expense of remelting the pig iron, which has to be done before it is sent into the electric furnace for the production of the steel.

We have also produced some spiegel and silico-spiegel of low percentages of the following compositions:

	S	Ph	Mn	Si.
Spiegel	0.015	0.060	11.25	3.30
Silico-spiegel	0.021	0.065	13.66	8.90

It is not necessary to speak here of the production of high-[illegible] alloys in our furnaces, as this has nothing to do with the problem of the production of pig iron from pyrite ashes.

Finally I wish to make a remark of a general character.

It is usually stated that the chemical reactions which occur in the electric furnace are identical with those which occur in the blast furnace. This is at least not exact; the more elevated temperature of the electric furnace and many other [illegible] easier to incorporate silicon, manganese, [illegible] with the pig iron, all of these bodies having a [illegible] reduction, while phosphorus and sulphur and [illegible] easily eliminated.

[illegible] the blast furnace a pig iron with 25 per cent silicon is relatively difficult, but it is easy in the electric furnace.

Reversely, in general an operator at first finds it very difficult to obtain pig iron with less than 7 or 8 per cent silicon if the ore is acid.

To produce a spiegel with 12 per cent to 14 per cent of manganese or a silicious spiegel does not require, according to our experiments, more than a slight rise (less than 10/100) in the energy, as compared with common pig iron, while the value of the product is considerably higher.

For example, a spiegel of 14 per cent costs 36 francs ($7.20) more than the pig iron, while the cost of the manganese ore (taking into account the losses) costs about 14 francs ($2.80).

In general terms, therefore, it is necessary to keep in mind the following points when comparing the electric furnace and the blast furnace:

(1) It is possible to use directly in the electric furnace impure ores which cannot be so used in the blast furnace.

(2) It is possible to use in the electric furnace coals of various coals of various kinds which cannot be used in the blast furnace.

(3) It is easy to make castings direct from the electric furnace, and it is also practical to convert on the spot rapidly the pig iron generated from a first furnace into special electric steel in a second refining furnace, while it is difficult to find a blast furnace in a locality where electric energy is cheap.

(4) In the electric furnace it is easy to incorporate with the pig iron silicon, manganese and other elements which raise its value and to eliminate those which diminish it.

This is true for every case in which pig iron is produced from ore.

As to the special problem of the utilization of the pyrite ashes for the production of pig iron, I have here described my investigations, thinking it possible that there may be other countries where the conditions are similar as in Italy—that is, lack of coal or iron ore, but plenty of water power and plenty of pyrite residues.

Societa Elettrochimica, Monza, Italy.

The Electrochemistry of the Solution of Gold in Potassium Cyanide.[1]

By John B. Ekeley and Arthur L. Tatum.

In 1893 McLaurin[2] proved definitely that gold will dissolve in potassium cyanide solution when there is oxygen present, but that, if no oxygen is contained in the cyanide solution, the gold remains unacted upon. From pure hydrocyanic acid and potassium hydroxide dissolved in water freed from air by long boiling, McLaurin prepared a solution of potassium cyanide. A Dumas bulb was partly filled with this solution, a strip of pure gold was placed in the neck of the bulb, and, while the solution was boiling, the neck was sealed. The gold was allowed to remain in the solution for 24 hours, the gold losing in weight 0.0002 grm. The gold was then allowed to remain in contact with the same solution in the presence of air for 24 hours, during which time it lost 0.0083 grm. This is the best experimental evidence we have that gold requires oxygen for its solution in potassium cyanide.

Although other investigators took up the study of the solubility of gold in potassium cyanide, little of any great value in a theoretical way was brought forward until Christy[3] took the subject up from an electrochemical standpoint, his work being published in 1902.

Christy made use of an Au, KCN, Hg_2Cl_2, Hg couple, measuring the electromotive force and finding that the positive current flows in the cell from the gold electrode to the mercury,

[1] A paper read at the fourth annual meeting of the Western Association of Technical Chemists and Metallurgists, Boulder, Colo., Jan. 6, 1909. From the *Western Chemist and Metallurgist*, the organ of the Association.

[2] *Journal of the Chemical Society of London*, Vol. 63, page 727.

[3] *Elektrochemische Zeitschrift*, Vol. 8, page 227.

gold going into solution and mercury being deposited. He then suggested that, should an "oxygen electrode"—that is, platinized platinum saturated with oxygen gas—be substituted for the calomel electrode, the gold would go into solution in the cyanide and the platinum would receive the same electrical charge that he found in the case of the mercury.

In support of this he performed the following experiment: A strip of gold was suspended in a solution of potassium cyanide that had been saturated with oxygen. A second strip of gold was suspended in a similar solution freed from oxygen by boiling and subsequently protected by a layer of oil. The two solutions were connected by means of a liquid bridge, and the two gold strips by means of a wire and galvanometer. Gold dissolved in the oxygen-free solution and a current was shown by the galvanometer to be flowing in the solutions from the oxygen-free solution to that containing the dissolved oxygen.

The following explanation of the phenomenon has occurred to us: Christy's cell is analogous to the simple cell constructed in the same manner by substituting zinc in sodium sulphate for gold in oxygen-free cyanide, and copper in sulphuric acid for gold in oxygenated cyanide. Here the current flows in the solutions from the zinc to the copper, zinc dissolving in one solution and hydrogen being liberated on the copper. The zinc dissolves in the absence of acid just as in Christy's cell the gold dissolves in the absence of oxygen.

In the zinc-copper cell the solution pressure of the zinc drives zinc ions into the solution, the hydrogen ions in the other solution being thus forced out, giving their charges to the copper, with production of a current outside the cell from copper to zinc. In Christy's cell, the gold on account of its solution pressure sends gold ions into the solution. Hydrogen ions in the oxygenated cyanide vessel (due to the slight ionization of water into H ions and OH' ions) tend to be forced out just as in the zinc-copper cell, but this does not occur. The dissolved oxygen sends, by virtue of its solution pressure, oxygen ions, O'', into the solution. These O'' ions with the H ions form OH', so that the cell acts like a bichromate cell or any other oxidation cell, instead of like a simple zinc-copper couple. The OH' ions thus left in the solution form with the K ions dissociated KOH.

In view of the above considerations, it seemed interesting to us to set up an Au KCN O — Pt couple. As expected gold dissolved rapidly in the cyanide, the rate varying with the concentration of the cyanide, and the concentration of the oxygen in the oxygen electrode, the current passing in the couple from gold to oxygen. Solubility determinations are needless and impossible on account of the difficulty of excluding air from the cyanide, and of the variability in the potential of the oxygen electrode.

If it were possible to supply oxygen to the platinized platinum at a high enough speed and at the same time exclude all air from the cyanide solution (other things being equal, such as physical condition of the gold, etc.), the solubility would undoubtedly be directly proportional to the current, according to Faraday's law. As a matter of fact, the physical condition of the gold varying and causing a varying occlusion of oxygen on its part, the oxygen held in solution by the cyanide, and the varying amount of oxygen occluded by the platinized platinum undoubtedly cause the gold to dissolve at a rate not proportional to the current flowing through the cell. Hence the solubilities indicated in the following table are not to be considered more than fair approximations.

Strength of KCN	Time	Au Dissolved	
0.05%	2 hr.	0.0219 grm.	Circuit closed.
0.05%	2 hr.	0.0030 grm.	Circuit open.
0.1 %	2 hr.	0.0307 grm.	Circuit closed.
0.1 %	2 hr.	0.0055 grm.	Circuit open.
0.15%	1 hr.	0.0193 grm.	Circuit closed.
0.15%	1 hr.	0.0033 grm.	Circuit open.

We also measured the potentials of gold in varying concentrations of cyanide against the oxygen electrode, with results which agree with the measurements of Christy and others made against the normal calomel electrode:

Strength of Solution.	Gold Potential.
0.1 %	0.12 volt.
0.15%	0.14 volt.
0.65%	0.21 volt.
0.8 %	0.22 volt.
1.0 %	0.29 volt.

The equation for the solubility of gold in potassium cyanide, often called Elsner's equation, is

$$4\,Au + 8\,KCN + 2\,H_2O + O_2 = 4\,K\,Au\,(CN)_2 + 4\,KOH$$

The gold dissolves on account of the formation of innumerable short-circuited gold-oxygen cells. The gold sends $4Au$ ions into the solution by virtue of its solution pressure, and at the same time the dissolved oxygen sends $2O''$ ions into the solution by virtue of its solution pressure. The $4Au^{\cdot}$ ions react with the $8CN'$ ions of the dissociated KCN, forming $4Au(Cn)_2'$ ions, and the $2O''$ ions react with $2H^{\cdot}$ (which are present from the dissociation of $2H_2O$ molecules into $2H^{\cdot}$ and $2OH'$), forming $2OH'$ ions. Thus the ions present before solution are

$$4Au^{\cdot} + 8K^{\cdot} + 8CN' + 2H^{\cdot} + 2OH' + 2O''$$

and after the reaction

$$8K^{\cdot} + 4Au(CN)_2' + 4OH'$$

or written in the form of an equation,

$$4\,Au^{\cdot} + 8K^{\cdot} + 8CN' + 2H^{\cdot} + 2OH' + 2O'' = 8K^{\cdot} + 4Au(CN)_2' + 4OH'$$

Oxygen need not necessarily be the carrier of the four negative charges required. Any substance capable of furnishing these charges would cause gold to dissolve in potassium cyanide, or any mechanical means of producing these four charges would have the same effect. In this latter case the equation would be

$$2Au^{\cdot} + 4K^{\cdot} + 4CN' + 2H^{\cdot} + 2OH' = 4K^{\cdot} + 2Au(CN)_2' + 2OH' + 2H$$

and gaseous hydrogen would be liberated from the cyanide solution as the solution of the gold proceeded.

Brom-cyanogen added to a potassium cyanide solution is a very effective gold solvent. The reaction is

$$Au_2 + 3KCN + Br\,CN = 2K\,Au\,(CN)_2 + K\,Br.$$

Considered electrochemically the reaction is as follows:

The solution pressure of the gold sends $2Au^{\cdot}$ ions into the solution while the solution pressure of the cyanogen bromide sends a Br' ion and a CN' ion into the solution. The $2Au$ ions react with the $4CN'$ ions, forming $2Au(CN)_2'$ ions, so that the equation would be written

$$2\,Au + 3K^{\cdot} + 3CN' + Br' + CN' = 2K^{\cdot} + 2Au(CN)_2' + K^{\cdot} + Br'.$$

It should therefore be possible to set up a cell in which gold and solid cyanogen bromide were the electrodes and potassium cyanide the electrolyte. The current would flow in the cell from the gold to the cyanogen bromide, both being consumed, just as in the gold-oxygen cell, the current flows in the cell from the gold to the oxygen, both being consumed.

Chemical Laboratory, University of Colorado.

W. H. Wahl.

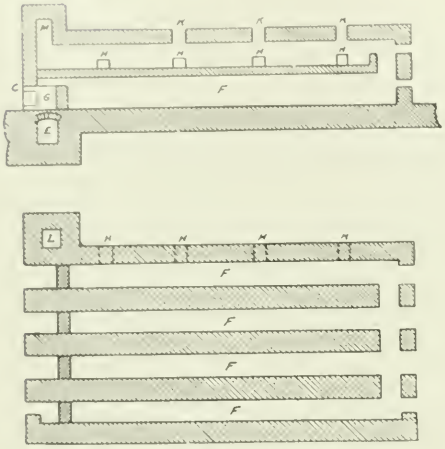
While going to press we learn of the death of Dr. W. H. Wahl, a noted metallurgist and writer on scientific subjects and for many years secretary of the Franklin Institute in Philadelphia, on March 23, at the age of almost 60 years.

Dr. Wahl, together with Professor Greene, was one of the first to study the use of aluminium as a reducing agent for refractory oxides, and produced in this way chromium and other metals free from carbon. But at that time the price of aluminium was so high that this method was only of scientific interest. Dr. Wahl also wrote a well-known book on electroplating. He was one of the founders of the American Electrochemical Society.

The Use of Producer Gas in Chemical and Metallurgical Industries.

By Dr. Oskar Nagel

In the January issue (page 30) I have discussed the use of gas fired furnaces for various industrial purposes.



FIGS. 1 AND 2.—CHLORIDIZING ROASTING FURNACE.

In the present article I will discuss specially the use of producer gas in the chemical industries.

In the manufacture of sulphuric acid (chamber process) there is little difficulty in obtaining 95 per cent acid in the platinum vessels, by the use of direct fire. If, however, 96 per cent acid is to be obtained, the use of producer gas is preferable, and the latter must necessarily be used for the economical and continuous production of 97 to 98 per cent acid, as with direct fire the proper heat cannot be kept up. The gas fired furnaces used for this purpose are of the usual reverberatory type, the passage of the products of combustion being arranged on the counter-current principle.

For chloridizing roasting producer gas is commonly used in Europe. Figs. 1 and 2 show such a furnace. From the producer, which is not shown in the cut, the gas goes through sewer *E* to channels *G* and *F*, then over the charge through flue *M* to stack *L*. The combustion air enters at *c* and, if necessary, also at the other end of the furnace. The material is charged through *K* and worked through doors *H*.

Another construction of a furnace for chloridizing roasting is shown in Fig. 3. The gas goes through *k* and *g*, the air enters through *h* and a working door.

A German furnace for melting soda is shown in Figs. 4, 5 and 6. Fig. 4 shows one-half of a furnace on line *CD*, Fig. 5 section *EF*, and Fig. 6 one-half of the hearth with the working doors *f*, *B* the flue, *e* the air regenerator, *c'* the gas regenerator. On account of the flue dust, vertical walls are used in these regenerators instead of the ordinary checker work. In order to remove the flue dust, the cover *d d* is lifted up and the dust pushed down into pits *e*, after removing a few bricks.

The use of producer gas in zinc smelting is one of its most important applications. A typical construction, as used near Freiberg, is shown in Fig. 7 (section *I K L M*), Fig. 8 (section *A B C D*), Fig. 9 (section *E F G H*) and Fig. 10 (section through reversing valves at *M N*); *a a* are the muffles, *b b b*

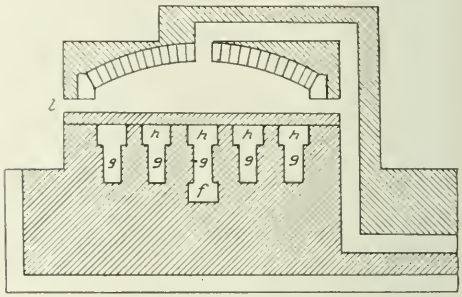
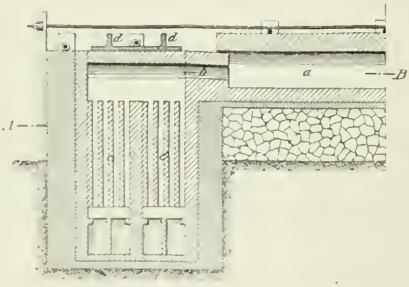
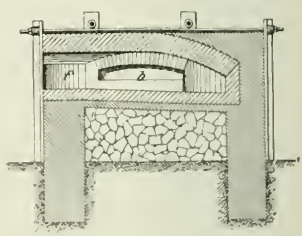


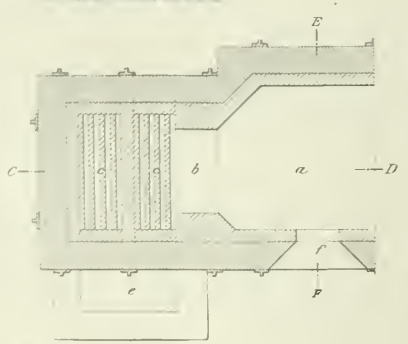
FIG. 3.—CHLORIDIZING ROASTING FURNACE.

the air slits, *b'b'b'* the gas slits, *c c* the air regenerators, *c'c'* the gas regenerators, *i i* the gas channels, *i'i'* the air channels, *g* the gas valve, *g'* the air valve, *k k* the pits for getting at the regenerators in case of necessary repairs, *h* is the main flue, *m m* the walls separating the prolongs, *o* the cleaning cover for the gas valve, *p* the air slide and *n* a cover, which is removed for changing the position of the valve levers.

In heating gas retorts with producer gas a saving of over 25 per cent is effected. The Schilling-Bunte furnace is shown in







FIGS. 4, 5 AND 6.—FURNACE FOR SMELTING SODA.

Figs. 11 to 14, where 1 to 6 are the air channels, α to ζ the channels for burning gas. The cold air enters at 1 into channel 1', goes backward, passes into channel 2 and comes again to the front, goes over to channel 3, passes backward, travels through 4 forward, upward to 5, goes backward through 5 into 6 to the slits, where it meets the gas. The burned gases go at α downward to β, travel here forward, in opposite direction to the air, go backward in γ, forward in δ (from here they go through channels δ and ϵ, which are arranged below the vaporizer), and in ζ backward to the stack.

Gas-fired furnaces for the regenera-

tion of bone-black have been in successful use since 1873. This process of regeneration requires great exactness and causes considerable expense, as the application of a uniform product, which can only be obtained by uniform temperature, is very important. By using producer gas, the cost of labor is greatly reduced, since, with a fair grade of fuel, the producer works practically automatically.

With gas firing the result of the process does not depend upon the intelligence of the workingman in charge; the temperature is easily regulated, and a great saving in fuel is effected. From time to time fresh bone-black is charged and at the same time a corresponding quantity of the regenerated product discharged.

There are in use furnaces with vertical or inclined cast-iron or fire-clay cylinders (retorts) of circular or oval cross-section of a diameter of 5 to 20 inches. The capacity of a furnace per 24 hours varies from 2½ tons to 15 tons.

There is no difficulty in applying gas-firing to furnaces of this kind. Figs. 15 and 16 show the firing of a furnace with 14 cylinders, with a capacity of 6 tons of regenerated bone-black per 24 hours.

The cylinders are arranged in two rows (seven in a row). In a similar way 12 to 15 cylinders can be set in one row. Between the two rows there is an open space of about 30 inches, which up to two-thirds of the height of the cylinders is reduced by two thin fire-brick walls to about 18 inches.

The gas from the producer goes through channel *g*, is regulated at *R* and passes into the furnace proper through an arch provided with a number of outlet slits. The air also enters through slits provided in this arch, as shown in Fig. 16 by dotted lines. The air is preheated by the sensible heat of the incandescent, regenerated bone-black, and travels parallel to the gas.

The size and arrangement of the slits depend upon the capacity of the furnace. The flame rises between the two brick walls and then falls downward, playing around the cylinders. The products of combustion leave through channels *f* to flue *F*. On their way they come in contact with the material, since the cylinders are perforated, thereby drying and preheating same and increasing the economy of operation.

A direct-fired furnace can be easily changed for operation with producer gas.

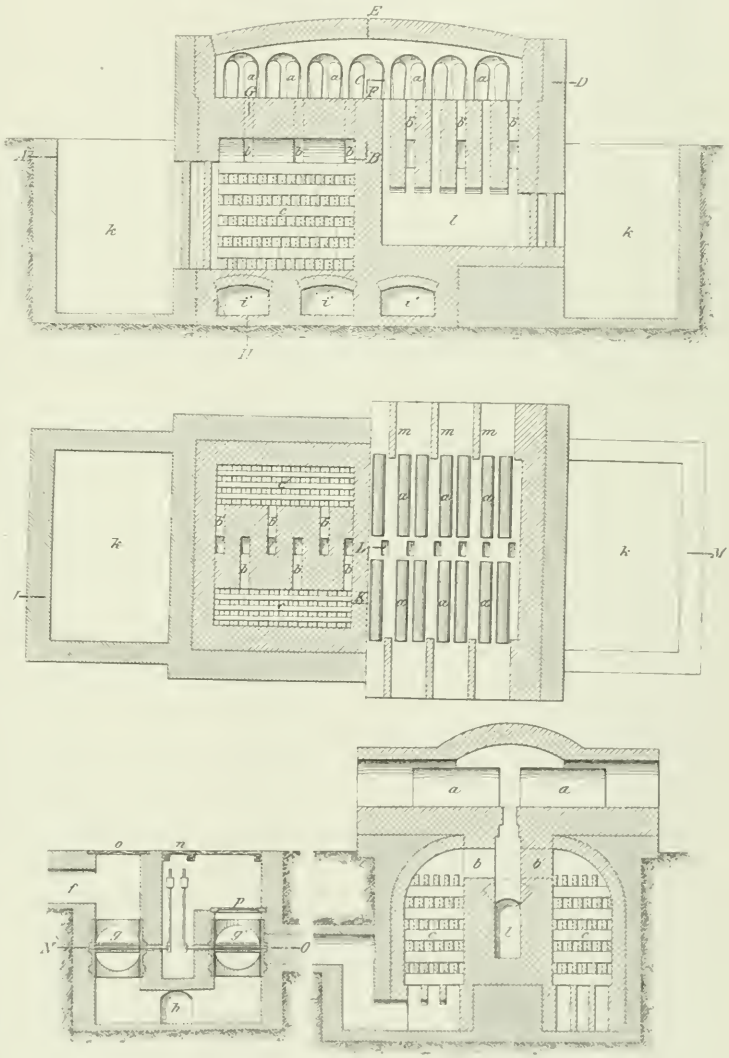
For observing the temperature peep-holes *r* are provided as shown in Fig. 15.

Two or more furnaces can be supplied with gas from one producer.

Electric and Fuel Furnaces.

By F. Louvrier

It is easy to foresee that within the next few years an important revolution will take place in the methods now used for the treatment of some ores, or, to be more exact, in the means employed to obtain them. We will speak of the substitution of



FIGS. 7, 8 AND 9.—SECTIONS OF ZINC FURNACE

electrical energy, as a thermic agent, for the usual combustibles, coal, coke, petroleum, etc.

At the present time electricity has completely conquered the metallurgy of aluminum; it is used in the manufacture of steel-alloys; it is about to absorb the manufacture of high-grade steels; its use in the treatment of zinc ores is but a question of a few months.

Such rapid progress enables one to forecast that at no distant

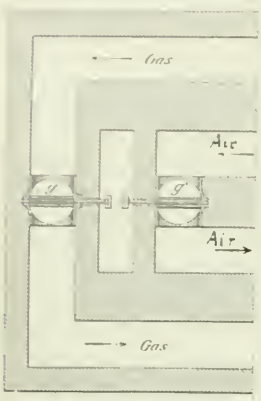


FIG. 10.—SECTION THROUGH REVERSING VALVES.

It is proper, therefore, at first to make a comparison between the two types, electric furnace and ordinary furnace, from the simple caloric point of view. In the ordinary furnaces the use of fuel always demands a blowing in of air, of more or less intensity. If, in some cases, the use of this air involves inconvenience (iron, copper, lead, gold and silver), it is not so in many others, for example, when the ores treated are oxidizing (tin) or very oxidizing and volatile (zinc) at their temperature of reduction.

Hence, there are several types of metallurgical furnaces using combustibles—those in which the ores treated are in direct contact with the fuel, and others, in which the ores are more or less completely separated from the fuel or from the products of combustion.

It is evident that the thermic efficiency of the first type is greatly superior to that of the second.

In the electric furnace no combustion takes place; there is consequently no oxidizing action, and it becomes possible to treat the more oxidizing and volatile metals (zinc) by putting them into direct contact with the source of the heat.

With this explanation we shall begin the comparison between the two types of furnaces, considering the most favorable case for the ordinary furnaces, namely, that of direct firing.

Direct-Fired Furnaces.—If we burn in one of these furnaces a molecular volume (12 grams) of pure carbon the reactions of combustion are reduced to one for perfect combustion.

$$C + O_2 + 4\,N_2 = CO_2 + 4\,N_2,$$

producing a molecular volume of carbonic acid with an evolution of 97.6 Calories.

The oxygen necessary for this combustion is one molecular volume. But as this oxygen comes from the air, it is consequently accompanied by a volume of nitrogen, which practically may be considered as four times the volume of the oxygen, i.e., four molecular volumes, as indicated by the formula of reaction given above.

The result is that the smoke escaping from the furnace is composed, at least, of one molecular volume of carbonic acid and four molecular volumes of nitrogen.

Without counting the heat lost in radiation, the heat used in the furnace is the difference between that produced by the combustion of the carbon and that carried away by the smoke and dust.

This latter can be easily calculated by the formula of M. M. Mallard and Le Chatelier

$$Q = a\frac{T - t}{1000} + b\frac{T^2 - t^2}{1000^2}$$

between two temperatures t and T under constant pressure, a being a constant common to all gases and equal to 6.5 and b a constant which has a different value for each gas, namely, 0.6 for the nitrogen and the oxygen, and 3.7 for the carbonic acid.

Applying this formula to the case of ordinary coke furnaces used in the treatment of copper, lead, gold, and silver ores, furnaces in which the normal temperature may be estimated at 1150° C. above the ambient temperature, we obtain for the heat of heating, per molecular volume, of nitrogen and oxygen at 1150° C., 8.65 calories, and for the carbonic acid 14.77 calories.

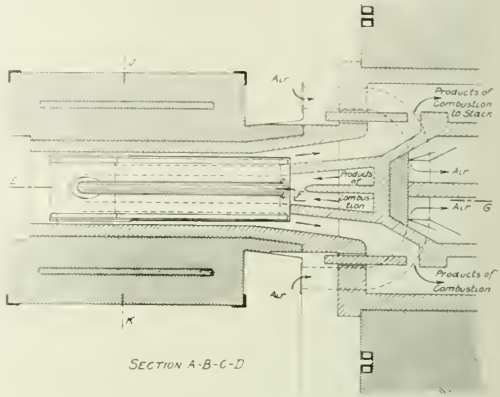


FIG. 11.—SCHILLING BUNTE FURNACE.

Consequently the quantity of heat carried away by the smoke in these furnaces is not less than:

$$8.65 \times 4 + 14.77 = 49.37 \text{ calories.}$$

This result is the one obtained by an absolutely theoretical combustion, supposing that the carbon used is chemically pure, that the quantity of air injected into the furnace is strictly the quantity necessary for combustion, and that the carbon is totally burned.

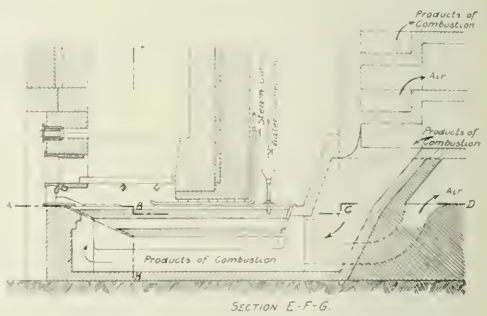


FIG. 12.—SCHILLING-BUNTE FURNACE.

But these three conditions are never realized in practice. The coke ordinarily contains about 9 per cent of incombustible impurities: a part of the coke (3 per cent as a minimum) is carried away by the smoke, under the form of particles (black smoke) without being burned, and there is always an excess of air injected.

This excess of air, even under very good practical conditions, is not less than 10 per cent, and in many instances it is as high as 60 per cent. Under good average ordinary conditions it may be calculated at 20 per cent minimum.

The result practically is that only $100 - (9 + 3) = 88$ per cent

of the weight of the coke is furnishing the heat, and that, therefore, the quantity of heat produced by the combustion of 12 grams of coke is not more than:

$$97.6 \times 0.88 = 85.88 \text{ calories,}$$

and that the quantity of heat carried away by this smoke is:

$$8.65 \times 4 \times 1.20 + 8.65 \times 0.20 + 14.77 \times 0.88 = 56.25 \text{ calories.}$$

Consequently the quantity of heat utilized in the ordinary furnaces employed for the treatment of copper, lead, gold and silver ores, and resulting from the combustion of 12 grams of coke is:

$$85.88 - 56.25 = 29.63 \text{ calories,}$$

which corresponds to a useful power of:

$$\frac{29.63 \times 1000}{12} = 2469 \text{ calories}$$

per kilogram of coke consumed, without taking into consideration, as stated, the losses by radiation.

In an electric furnace of the resistance type, if we also exclude these losses, the electrical energy is entirely converted into heat, so that one electric horse-power per year gives

$$\frac{75 \times 3600 \times 24 \times 365}{419} = 5,645,000$$

useful calories, and, therefore, is equivalent to:

$$\frac{5,645,000}{2469} = 2285 \text{ kilograms}$$

of coke burned in the ordinary furnaces.

As the radiating surface of an ordinary furnaces is, at least, five times that of an electric furnace of the same production, and, as in the former, the maximum temperature is produced near the walls of the furnace, while in the latter this maximum temperature is obtained in the center of the materials to be treated, the certainty is that the losses by radiation are, at the least, five times greater in the ordinary furnaces than in the electric furnace.

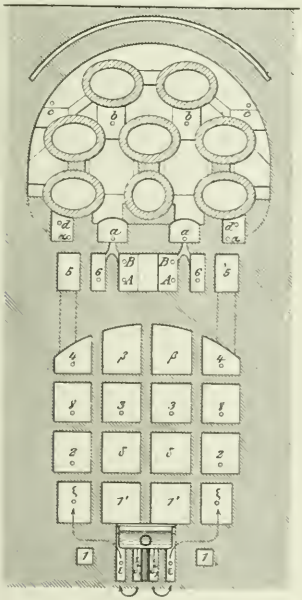


FIG. 13.—SCHILLING-BUNTE FURNACE.

Taking into account these losses, we arrive at the following conclusion:

One electric horse-power per year is equal to 2500 kilograms of coke consumed in the ordinary furnaces.

Let us make a comparison between the costs of the two thermic agents employed to obtain the same result

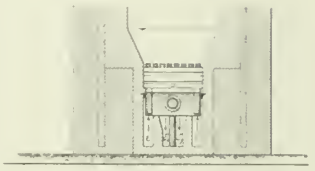


FIG. 14.—SCHILLING-BUNTE FURNACE.

At Livet, France, electric energy is rented at a cost of 25 francs per horse-power year, i. e., at less than $5. Dr. Haanel, Director of Mines in Canada, assumes the possibility of a cost of $4.50 in his country; at Nottoden, Norway, electrical energy is rented at the rate of 23.00 francs per horse-power per year, i. e., at less than $4.60. In Mexico we know of numerous waterfalls capable of furnishing electrical energy at a price that will not exceed $5. Taking these figures, $5 would not be an unfair price under favorable conditions: nevertheless, and with the object of understanding the price of electrical energy, we assume the cost of one horse-power to be $6 and we fix at $5 the cost of one ton of coke delivered at the mines, in countries where fuel is cheap (United States, most countries in Europe, etc.).

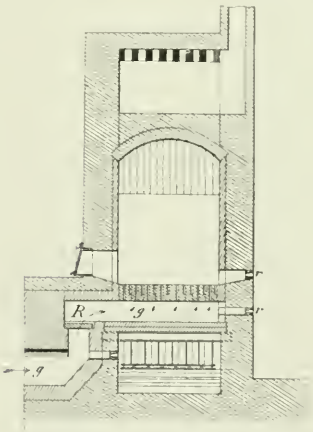


FIG. 15.—BONE-BLACK FURNACE.

Under these conditions, where electrical energy is very cheap, $6 in electrical energy is equivalent to: $5 \times 2.5 = \$12.50$ of coke; i. e., the employment of the electric furnaces is $12.50 : 6 = 2.08$ times cheaper than coke furnaces, in countries where fuel is cheap. Making the same comparison in countries where fuel is dear (Mexico, Central and Southern America, Africa, etc.), and taking $12.50 to be the cost of one ton of coke delivered at the mines (this cost is much lower than the average in the countries mentioned; cases can be cited in Mexico in which the cost is over $30), the following conclusion is reached: $6 in electric energy is equal to $12.50 \times 2.50 = \$31.25$ in coke, which is equivalent to saying that the employment of electric furnace is $31.25 : 6 = 5.208$ times more economical than coke furnaces in the atment of such ores as copper, lead, gold and silver ores

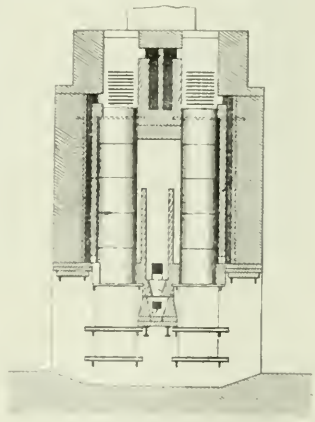


FIG. 16.—BONE-BLACK FURNACE.

[illegible] economy must be added the other numerous [illegible] obtained from the use of the electric furnace, and [illegible] summarized as follows

1 Great facility in the regulation of the heat by the simple [illegible] of the electrodes

2 Constant production of the exact heat necessary, no more [illegible] necessity

3 Entire elimination of the chilling of the slags, so prejudicial [illegible] coke furnaces

4 Easy treatment of all classes of ores, no matter how refractory

5 Higher percentage in recovery of metals as a consequence of (a) the non-oxidizing action of the electric heat, which is produced without air or oxygen; (b) the production of lesser quantity of slags, and the greater fluidity of these.

6 Decrease in manual labor: (a) due to lesser quantity of materials to be handled; (b) because the ores can be treated as they come from the mines without the necessity of having [illegible] broken or bound when in dust

7 Complete suppression of blowers and tuyeres.

8 Decrease in expenses of maintenance and repairs due to the maximum temperature being in the center of the ores treated, and not on the walls of the furnace, as in ordinary furnaces

9 Production of a purer product, the electric heat being chemically neutral and not conveying to the metal the impurities always contained in the usual fuels.

10 Possibility to operate profitably mines situated far from means of communication, due to the facility of transmission of the electrical energy

11 In all cases, decreases in transportation expenses, due to the facility of treating the ores even at the mines.

12 Yields as high from smaller plants as from larger ones

So many important advantages, combined with the economy obtained, give to the electric furnace an indisputable superiority over the coke furnaces in all and every case, if the electric energy is as cheap as assumed, but, above all, in countries where coal and coke are dear and means of communication difficult and rare. Therefore, the employment of the electric furnace as a substitute for coke furnaces cannot be doubtful in the treatment of iron, copper, lead, gold and silver ores, in all countries where a natural source of energy, a waterfall, for instance may be disposed of.

In this case, the treatment in electric furnaces will certainly be always much more economical even than the cyaniding process in treating gold and silver ores, and has, besides, the advantage of recovering a greater percentage of metals—95 per cent as a minimum against the 87 per cent gold and 80 per cent silver

It is evident that the economies effected by the use of the electric furnace against the use of fuel as a thermic agent will be greater as the normal working temperature of the furnace increases, because the thermic efficiency of the ordinary furnaces decreases very rapidly as the temperature increases.

If we consider the treatment of iron ores, which demands a temperature of 1500 deg. C. as a minimum, the thermic efficiency obtained from a direct fired furnaces will be excessively low; in this instance, the recovery of a part of the heat carried away by the smoke is indispensable

By means of this recovery it could easily be shown that one horse-power per year is equivalent to 2800 kilograms of coke [illegible] in ordinary blast furnace

Furnaces in which the Ore is not Fired Direct—As has been [illegible] electrical energy is much more economical than [illegible] power in metallurgical furnaces of direct [illegible] (the natural result, therefore, is that the economies [illegible] will be still greater in furnaces where ore is indirectly [illegible] very low its fuel efficiency, while the electric [illegible] has a maximum efficiency, because the ores treated by it always are in direct contact with the source of heat.

Therefore, the following equivalences are obtained, which, with the ones given above, are corroborated by practice:

1. In the furnaces used for the *treatment of tin ores, one electric horse-power per year is equal to* 3600 *kilograms of coke,* and yields a greater quantity of tin, because this metal is neither oxidized nor carried away in the form of vapor by the smoke.

2. In the furnace employed in the *treatment of zinc ores, one electric horse-power per year is equal to* 8000 *kilograms of coal,* and the percentage obtained is not less than 95 per cent zinc, against the 85 per cent obtained by the ordinary processes.

3. In the manufacture of *crucible steel, one electric horse-power per year is equa. to* 18 *tons of coke,* this proportion being due to the high temperature required (1050 de. C.).

Finally, when it is necessary to obtain temperatures above 1700 deg. C., which is exceedingly difficult in ordinary furnaces, the employment of the electric furnace becomes absolutely indispensable. It is this which explains the present use of the electric furnace for making certain ferro-alloys.

As the generation of one electric horse-power per year produced in gas engines calls for a consumption in coal of not more than 3855 kilograms (440 gr. per horse-power per hour), it can be concluded that in the treatment of tin ores, and, above all, of zinc ores, as well as in the manufacture of steel alloys and crucible steels, the use of electric furnaces is more advantageous, even should the electrical energy be produced by thermic engines consuming fuel.

Examining the numerous advantages of the electric furnace described above, it may seem strange that its use has not been developed to a greater extent. To account for this, it must be borne in mind that electric science is still comparatively new; that the electric furnace has been but slowly perfected, and only in the most recent years; also that any innovation, no matter of what nature, modifying an established order of things, always encounters difficulties in application.

Actually, these difficulties as regards electrometallurgy have disappeared, or are about to disappear; the generation and transmission of electrical energy is now well understood, and electric furnaces have been greatly perfected.

Therefore, it seems that there is no question that the use of the electrical furnaces will be rapidly developed, and that in a number of years we shall witness these furnaces exclusively in use in all cases for the treatment of tin and zinc ores (without referring to the other metals employed in a lesser degree), and also in the smelting of iron, copper, lead, gold and silver ores, wherever an electric horse-power per year can be obtained at a cost less than three times the cost of a ton of coke.

Mexico City.

Physical Chemistry and Electrochemistry at the College of the City of New York.

By Leo Frank Guttmann, Ph.D., F. I. C.

The physical-chemical laboratories of the College of the City of New York are situated on the ground floor of the Chemistry Building and comprise the main laboratory, an electro-analysis room and an adjacent electric-furnace room.

The main laboratory faces northeast and contains three tables with working places for 12 students at each, and a narrower table provided with a glass top with six working places. Five hoods with glass sides and porcelain-tiled backs are ranged along the south wall, and one open sheet-iron draught hood is placed over the blowpipe table. A large thermostat of the Ostwald pattern is placed in the corner between the end hood and a window.

A row of five windows faces the hoods, and use is made of the extra wide window shelves to place balances thereon. Ana-

lytical balances weighing to 1/10 milligram are provided for calibration purposes, and one other of a more sensitive pattern, as well as a large one carrying up to 1 kg with a sensibility of half a milligram.

Three sets of glass shelves with five tiers are provided for reagents, and a blackboard, book shelf and cabinet for apparatus complete the equipment.

The general arrangements are the same as those in the rest of the Chemistry Building. The laboratory is supplied at each hood with an H_2S outlet consisting of a hard rubber valve connected to large Parsons generators in the basement, gas, water, steam, vacuum and compressed-air outlets. The main sink is

FIG. 1.—ELECTRO-ANALYSIS ROOM.

supplied with hot and cold water and one distilled water outlet, while the small sinks attached to the laboratory tables are provided with two cold water outlets only. The sinks are of porcelain and of the roll-rim flush pattern.

Artificial ventilation supplied by motor driven fans is used for the laboratories, and a separate powerful exhausting system ventilates the fume hoods.

All main pipe lines are carried exposed suspended from the ceiling, so as to be readily accessible for repairs. Each line can be completely shut off by means of a floor valve, so that repairs needed in one laboratory do not incapacitate the remaining laboratories on the same floor.

The chief feature is the arrangement of the pipe lines (gas, vacuum, compressed air, water, direct and alternating current and storage-battery current), which are carried along the center of each table in a raised enclosed trough of alberene. By this means all obstructions are avoided, and any accidental spilling of liquids cannot foul the current outlets which are raised 2 in. above the level of the table top. As in the other laboratories, all table tops and hood bases are of alberene.

Two low alberene tables placed on concrete piers are provided for two D'Arsonval galvanometers of the Nadler, and Leeds & Northrup pattern. One of these galvanometers is connected by means of a five-way plug switch to as many working tables, thus enabling several students to perform identical experiments (say, with thermocouples).

The large thermostat is kept at 25°, a smaller one being used for various temperatures. The laboratory is equipped with several motors, both hot-air and electric, for stirring purposes, with a larger one with universal movement (Koehler) and with a selected stock of physico-chemical apparatus. There are besides a set of mercury pipettes and burettes for gas analysis according to Ramsay and Travers, a Wilson electroscope, several ordinary tin can electroscopes with telescopes for radioactivity determinations, a Ramsay-Toepler vacuum pump, a standard Weston cell, a set of D. R. volumetric apparatus, and a good blowpipe for glass blowing.

Communicating through a side door is a small private laboratory for the instructor, containing besides the usual equipment an electrolytic panel similar to those placed in the electro-analysis room. Students' reports on the work done are handed in on large cards, which can be folded and filed for reference.

The electro-analysis room is equipped with 14 working places, each place containing an electrolytic panel with three measuring instruments protected by a glass front, a rheostat, a knife switch and direct and storage-battery current outlets. The arrangement is according to Prof. Edgar F. Smith, of the University of Pennsylvania.

The measuring instruments comprise one ammeter, 0 to 1 amp, graduated in 100 divisions, a second one 0 to 25 amp, with 1/5 amp graduations, and a voltmeter reading to 50 volts in half-volt divisions. The enamel type rheostat has a total resistance of 172 ohms.

The electro-analysis room likewise contains the big distributing board for storage battery current, which controls every outlet in the building. It consists of a vertical marble slab provided with copper lined equidistant holes. Each pair of holes is numbered and leads to the correspondingly numbered outlet in any laboratory. Current is furnished by connecting the two outlets by means of flexible cables with the power board.

The power board contains five busbars, each provided with 24 distributing sockets, and connected to four batteries in the accumulator room. The batteries are connected in series with the busbars, giving an e.m.f. of 4 volts between the first two busbars, 6 volts between the second and third, and third and fourth, and 8 volts between the fourth and fifth, a total of 24 volts between the two end busbars. By this means any desired voltage from 4 to 24 volts (with the exception of 18 and 22) in 2-volt steps can be obtained.

The accumulator room is in the basement and contains 48 chloride cells. These have a discharge rate of 60 amp in one hour and 120 amp hours capacity on an eight-hour discharge.

The cells are permanently connected as follows. One battery

FIG. 2.—[illegible] INSTRUMENTS.

of eight cells connected two in series and four in parallel, giving 4 volts and capable of discharging at the rate of 60 amp for eight hours; two batteries of six cells each, connected three in series and two in parallel, giving 6 volts with a discharge rate of 30 amp for eight hours; and one battery of eight cells connected four in series and two in parallel, giving 8 volts and of the same discharging capacity as the 6 volt batteries. The remaining 20 cells are connected in series.

The 6-volt and 8 volt batteries can be discharged so as to

125 volts for one hour, and the 4-volt battery can give 240 amp in one hour. By means of a double-pole, double-throw knife switch of 50-amp capacity each of the 6-volt and 8-volt batteries can be connected in series for charging purposes. A similar arrangement with three knife switches enables the 4-volt battery (four in parallel) to be connected in series, giving 16 volts. The motor generator can then be used to the best advantage, and each cell be charged at the proper rate of 15 amp.

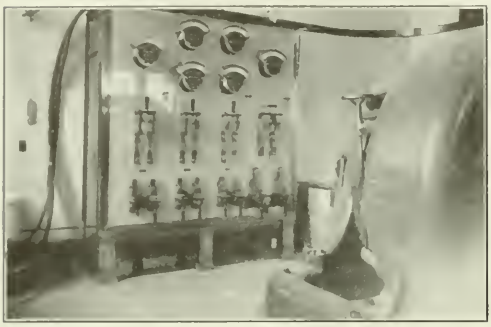


FIG. 3.—ELECTRIC-FURNACE ROOM.

One hundred-ampere fuses are placed between the busbars and the leads to the respective batteries in the accumulator room.

The charging outfit comprises a motor-generator giving 20 amp up to 125 volts, a switchboard provided with an ammeter reading to 25 amp, and a 125-volt voltmeter, both instruments with illuminated scales, various knife switches, starting and controlling rheostats and cut-outs. The charging leads are led directly to two sockets on the distributing board in the electro-analysis room, and connection is made there with the cells to be charged. Two portable cables in the accumulator room likewise lead to two outlets on the distributing board so that any number of cells can be permanently assigned for a specific purpose, or the condition of any cell investigated in detail. By these means the accumulator room need never be entered except for inspection.

Current is supplied to the user at the voltage and current asked for, a suitable fuse being inserted in the cables making

FIG. 4.—PHYSICO-CHEMICAL LABORATORY.

the connection on the distributing board. On disconnecting any charged cells, the user is asked to state the approximate number of ampere-hours taken from them. A record of this is kept for each battery, and it is then easy to tell how much charging is required. The cells in each battery being used up at the same rate are always in a comparable state, and any individual cell is thus always protected from being run down by a careless user.

A portable voltmeter, reading directly to 0.1 volt, is provided for testing the cells. All current cables can carry up to 50 amp, but, as a rule, 5 or 10 lamp fuses are inserted in the connecting cables on the distributing board. Arrangements are now being made to simultaneously supply 56 freshman desks with current at 4 volts from the 4-volt battery.

A room for spectroscopy, finished in black and equipped with students' instruments as well as with two accurate spectrometers, adjoins the electric-furnace room. The latter is equipped with generators and transformers capable of giving up to 3000 amp at 15 volts, the current being distributed through cables pivoted on a central iron beam. Open draught hoods are ranged along the side of the room and the electric furnaces, which are built as required, will be placed under them.

A word should be said as to the projection-lantern equipment of the lecture theater and lecture room. While the projection lantern is being prepared for demonstration, the lecture rooms can be darkened by means of black window shades actuated by electric motors, thus affording a considerable saving in time.

The above description is published with the sanction of the Director of the Department of Chemistry.

The College of the City of New York.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

The Faraday Society.

On February 9 Dr. S. Rideal read a paper on the "Application of Electrolytic Chlorine to Sewage Purification and Deodorization by Oxychloride" (see p. 168). The discussion was opened by Mr. H. C. H. Shenton, who said that, speaking as an engineer and not as a chemist, he had, in association with Mr. W. Pollard Digby, several years ago advocated the sterilization of sewage effluents and some of the criticisms then advanced he would now meet. The difficulty arising from storm water had been much overrated; for storm rushes were not continuous, but only of short duration. Some sanitary authorities were opposed to sterilization; but as a rule they could give no valid reason, and their dislike of sterilization arose from their complete ignorance of the subject. The practicability of the process had been demonstrated, and it was decided on at Baltimore, U. S., and at Hamburg. He considered that manufacturers of hypochlorite plants were themselves largely to blame for the prevailing ignorance; but official apathy was also responsible; and the extent to which pollution of the river Thames and of the Lee is permitted, was most reprehensible. The Local Government Board had long ago sanctioned a scheme of his for the river Lee, but nothing had been done. At last, however, the practicability of sterilization was beginning to be recognized.

Mr. Edward John Silcock, in his inaugural address, as president of the Society of Engineers, on February 1, had said: "As to whether or not any of our present systems of purification are sufficiently effectual to purify the sewage of a town and discharge it into a river, the water of which is subsequently used for domestic consumption, is open to doubt. Recent investigations indicate that the effluent from even the best land treatment contains bacteria, some of which may be pathogenic; and that the effluent from a bacterial system of purification contains at least an equal number of bacteria. Under these circumstances it is probable that the future trend of scientific opinion will be in the direction of requiring the effluent from works so situated to be sterilized before being discharged into the river."

Mr. A. J. Martin differed from the last speaker as to the storm water question, and considered it a much more formidable difficulty than Mr. Shenton did. A storm rush might amount to from 20 to 50 times the ordinary flow, to deal with which necessitated an enormous plant capable of being brought into action

instantly. An important feature in favor of chlorine was its prevention of the clogging of the pipe-heads.

Mr. W. Pollard Digby, while fully recognizing the value of the bacteriological side of the paper, regretted that on the electrochemical side data should not have been furnished which would be of any relative value in the records of hypochlorite production. There was no desire to ask for details of construction which might be regarded as works' secrets; but nothing was said as to the utilization of the diaphragms. He had experimented with cathode and anode diaphragms several years ago; and more recently had found considerable advantage in the use of double diaphragms keeping the main body of the electrolyte from contact with either of the electrodes. The society was entitled to ask for details both of application and manufacture. Neither the strength of the solution at which the stated efficiency was obtained nor the salt consumption in relation to available chlorine were given; and in view of the advantages claimed it was legitimate to ask for tangible proof. He could claim to be, with Dr. Rideal, one of the pioneers of sewage sterilization, but Dr. Rideal was the missionary pioneer, and his work at Maidenhead and Guildford had been of much value and interest.

These results were followed, in the United States, by the work of Phelps, Carpenter, Kellerman, and others, and showed that sterilization of sewage was practicable cheaply. Catchment areas are limited, and when one realized the cost of a Welsh water scheme for London, it was obvious that great capital outlay can be saved if the water authorities insisted on the sterilization of sewage effluents entering the Thames, although that would not obviate the necessity for care and precaution at the waterworks. It would be well to restrict fancy names to the apparatus, and to call the chlorine solutions by their proper chemical names.

In the paper a distinction was made between the old "oxychloride" and the new "oxychloride," which merely serves to show that the same material may be well made or badly made—reserving the latter adverb for unstable solutions which part with their chlorine at too rapid a rate. All who made hypochlorite solutions with the view of obtaining a stable product are in the habit of watching temperatures and employing means which they do not talk much about—except Dr. Alexander, whose policy is that of frankness itself; and he wished the Oxychloride Company were half as frank in regard to efficiencies and methods of working. He did not see any hope for a carboy trade to small sewage works. Nearly every sewage works has motive power available; and, even taking a 15-gram solution, transport would entail payment for a very large quantity of water plus a certain amount of useless salt per unit of available chlorine. Chemical manufacturers supplying "chloride of lime" would be in a better position because that substance is compact and gives a greater quantity of chlorine per unit of waste.

Mr. A. B. Thomson said there was a difficulty in giving definite figures as to the cost of the process; it would be regulated to a great extent by the expenditure for power and materials which varied in different localities. He was not able to agree with Mr. Digby's statement that the distribution of hypochlorite in carboys was hopeless, since electrolytic chlorine was superior to chloride of lime for sterilizing purposes and was free from defects appertaining to it such as clogging of filters by the suspended lime.

Mr. I. Fieldhouse remarked that the supply of the requisite quantity of hypochlorite for a storm-rush was secured by an automatic valve regulating its flow from special storage tanks.

Mr. J. H. Johnson pointed out that the purification of sewage has been demonstrated by recent research to be essentially physico-chemical, and not bacterial, by reason of sewage containing much matter in colloidal solution.

Mr. F. E. Pollard objected to the repeated use of the word oxychloride in the paper in such a manner as would lead those unacquainted with the fact that oxychlorides are not capable of giving rise to the liberation of nascent oxygen to suppose that the active substance is really an oxychloride. The names of chemical products should be such as would accurately set forth their constitution.

Dr. Rideal replied briefly, and remarked that the constitution of the electrolytic liquid was surrounded by considerable uncertainty. The general supposition was that the electrolysis of the salt solution resulted in the production of hypochlorite; but recently he had ascertained the presence of chlorite. He had not found that any chlorate was formed when working with a cold solution, whether diaphragms were employed or not.

The Aluminium Corporation.

The adjourned statutory meeting was held on February 17. Mr. A. H. Gibson, chairman, after reciting the various liquidation schemes which had been put forward, said, on February 3 the liquidators received a letter from the British Aluminium Company offering to purchase the undertaking on the following terms: £50,000 in cash for the assets; 10,000 fully-paid 6 per cent £5 shares; and 90,000 6 per cent preference shares of £5 each, of which £2 10s. 0d. had been paid, leaving a liability in the last named shares of £24,500. So that the terms were briefly —£50,000 in cash; £50,000 fully-paid preference shares, and £24,000 partly-paid shares. Mr. Graham had some correspondence with Mr. Touche on the matter, and the latter gentleman replied in answer to a question that if it was preferred, the partly-paid shares would be eliminated from the terms. There were also further conditions named by the British Aluminium Company as to the contracts made by the Aluminium Corporation. However, after looking at the matter from all points of view, the liquidators had come to the conclusion that it would be better to reconstruct the concern than to sell it.

Mr. Scott, chairman of the creditors' committee, said that he regarded the reconstruction scheme as being more favorable for them than being taken over by the British Aluminium Company. Obviously the scheme was the better one, as the creditors besides getting cash got shares in well-secured stock. The creditors felt that the shareholders through their liquidators had had a fair term of putting the business right, and they considered that they should now appoint a sole liquidator. He accordingly moved a resolution to the effect that Mr. Robertson Lawson be appointed sole liquidator of the company, and that Mr. Scott in conjunction with the other members of the creditors' committee, be authorized to make such application before the court.

Mr. Robb moved a resolution providing that in the event of the liquidator not being appointed on or before February 27, the date when the winding-up petition will be heard, his clients (Messrs. Brownlie & Murray) should make an application for a liquidator to be appointed.

After discussion this was defeated, and Mr. Scott's resolution was carried.

Russian Platinum Monopoly.

Most of the platinum producers in the Ural have for years past been bound (according to the St Petersburg correspondent of the Berlin *Tageblatt*) by a contract to deliver the whole of their output to an English firm; but as the latter paid a lower price than the French firm of Bonardelle, with whom the remaining Ural producers were working, the majority have now resolved to pay the indemnity provided for in the contract, and to dissolve the business connection with the English firm. All the producers in the Ural are forming jointly with the French firm in question a company for the working of the Tagilsk mines, the French firm taking over shares to the extent of 6,000,000 roubles (£600,000). The minimum price for platinum has been fixed at 28,000 roubles per pood, or considerably higher than at present. It is added that the question of establishing a monopoly in platinum has again been raised, and a conference is about to be held at St. Petersburg under the

[illegible] of the Ministry of Commerce for the [illegible] regulating the trade in the metal

[illegible] in the *Chemical Trade Journal* it appears [illegible] when the price of platinum was low, a foreign [illegible] to buy up the smaller platinum concerns [illegible] entered into an advantageous contract with the [illegible] and Schuvaloff houses. This syndicate (not [illegible] gradually acquired control of the whole Rus[illegible] output, and the smaller producers find themselves obliged [illegible] their concerns to it at practically any price. This has resulted in an agreement among the producers, who are now endeavoring to get the government to regulate the industry. [illegible] foreigners are trying to combat by allowing the price [illegible] to rise.

High-Speed Tool Steel.

[illegible] announcement of Professor Arnold, of Sheffield University, that within a year, a British steel of quadruple the [illegible] power of any steel now known would be on the market caused great expectations, but inquiry of the well known firm whose name was given in connection with the matter—Messrs. Jessop & Colver—has failed to elicit confirmation of Professor Arnold's statement, and the Sheffield steel manufacturers have protested strongly against the same, for they say it has led to the countermanding of orders for old qualities of high-speed steel and has caused serious loss in the trade.

Market Prices.

The market prices during February, 1900, were as follows:

Tin.—After a drop at the beginning of the month to £123.15s., the price rose in jerks, principally between the 4th and 11th, to £128.5s. on February 23. Since then the fluctuations have been [illegible] heavy, price on the 29th, £129 to £130.

Copper has had a downward tendency, recovering slightly from £57.0s. on the 1st to rise to £59.2.6 on the 10th, and drop [illegible] to £56 to £57 at the end of the month.

Spelter [illegible] has been inclined to rise from £13.10.0 on the [illegible] to equal price, £13.15.0 commencing to improve about the [illegible] fluctuations.

Lead drooped on the 3d from £2.17.4 and continued down [illegible] £2.16.4 on the 10th, generally flat to £2.16.0 on the 26th. Sheet lead [illegible] has been in a depressed condition, varying from £2.8.0 to their present price, £2.7.0.

Silver [illegible] has shown a downward tendency; opening above £28.0.0 it has dropped steadily during the month to the neighborhood of £26.0.0.

[illegible] at [illegible] Liverpool	£11	7 6
[illegible]	21	0 0
[illegible]	11	[illegible]
[illegible]	4	5 0
[illegible] Sheet [illegible]	21	0 0
[illegible] [illegible] Ounce Standard, per cwt.	5	[illegible] 0
[illegible] [illegible] per cent. per annum		[illegible]
[illegible] [illegible] per cent. per annum		[illegible]
[illegible] [illegible] per ounce		2 5/8
[illegible] [illegible] per cwt.		9
[illegible] [illegible]	7	3
[illegible] [illegible]	8	[illegible]

Shipment of Calcium Carbide.

[illegible] the recent discussion of alleged danger in the [illegible] of [illegible] chemicals and especially of calcium carbide should [illegible] interest. They are taken from a very useful little book [illegible] Wynne Codrick & Co., of New York City, entitled [illegible] Shipping.

The United States statute prohibits the shipment, among other [illegible] of [illegible] strongly inflammable naphtha, benzine, benzole, coal oil, [illegible] or crude petroleum, or other like explosive-burning [illegible] or [illegible] articles packed as freight or as stores on [illegible] carrying passengers. Under the provisions of the [illegible] every person knowingly transporting or delivering any of the articles above referred to on a steamer carrying passengers renders himself liable to a fine. It is, therefore, incumbent upon shippers always to obtain a "special permit" from the transportation company before making delivery of cargo of hazardous or inflammable nature.

By virtue of a circular issued by the Secretary of Commerce and Labor calcium carbide may be transported on vessels carrying passengers when the carbide is contained in steel drums or steel receptacles, the seams of which are lapped and properly riveted or fastened in such a manner as will best insure the maximum strength of the joints, and when the said drums or receptacles are fitted with double covers, so that such drums or receptacles shall be water-tight as well as air-tight during the transportation. For packages weighing 110 lb. or less the drums or receptacles shall be made of open-hearth steel of not less than No. 26 gauge. Packages weighing more than 110 lb. must be placed in drums or receptacles constructed of open-hearth steel of not less than No. 24 gauge. In addition calcium carbide or carbide of calcium may also be transported in cans containing not more than 10 lb. each on vessels carrying passengers.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Melting Furnace.—To add ferromanganese to steel, W. Schemmann and J. Brown, of Rombach, Germany, recommend to add the ferromanganese in liquid form, for reasons explained at some length on another page of this issue under Recent Metallurgical Patents. They have devised a

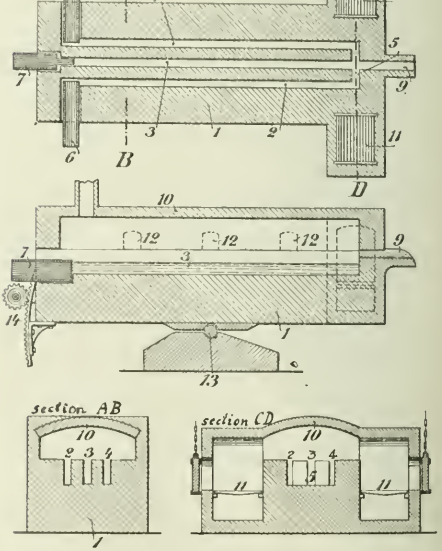


FIG. 1.—ELECTRIC FURNACE FOR MELTING FERROMANGANESE.

special melting furnace, four sections of which are shown in Fig. 1. It is intended for use on a three-phase system and has, therefore, three electrodes, 6, 7, 8. The modern ferromanganese is contained in the three gutters, 2, 3, 4, which lead into a common crossgutter 5. The molten ferromanganese is tapped through the tapping hole 9 simply by tilting the furnace. But

the capacity of the melting furnace is made 5 to 10 times the amount taken out at each tapping. Whenever some molten metal is taken out, new solid ferromanganese is added and the furnace remains in continuous operation. (915,488, March 16.)

Carborundum.—According to the well-known method of manufacture of silicon carbide, a mixture of pulverized coke sand, salt and sawdust is subjected to great heat in an electric furnace. The resulting product is a loose aggregation of crystals of various sizes with a considerable proportion of interstices in the crystal mass. Mr. Frank J. Tone, superintendent of the Corborundum Company, has discovered that if porous masses of silicon carbide be embedded in a body of silica and carbon, and the latter be heated to the temperature of formation of silicon carbide, preferably by passing the electric current through a central conducting core of carbon, the vapors of silicon and carbon or their compounds will build upon and in the mass of silicon carbide crystals, and will convert it into a dense compacted and non-porous state. While not being able to state positively the nature of the reaction, Mr. Tone attributes it to the reversibility of the reaction

$$2\,SiC + SiO_2 = 3\,Si + 2\,CO$$

He believes that silicon has the property of reducing CO at certain temperatures just below the decomposition temperatures of silicon carbide and that the silicon carbide thus formed is deposited in the pores of the crystalline mass, making a dense compacted form. (913,324, Feb. 23, 1909.)

Precipitation of Copper.—A patent of Mr. Arthur Ramen of the Helsinghors Kopparverks, at Helsingborg, Sweden, refers to the precipitation of copper from the solution obtained from the ores after chlorinating roasting. Part of the solution is treated with metallic iron to precipitate cement copper. The other part is electrolyzed in the cathode chamber of a diaphragm cell, while the anode chamber is filled with the ferrous-salt solution, resulting from the precipitation of copper by means of iron. The object is, of course, to reduce as much as possible the voltage required at the terminals of the electrolytic cell. (913,430, Feb. 23, 1909.)

Gas Cell.—If an electrode of porous carbon, the pores of which are filled with oxygen, is placed with an iron electrode into a suitable electrolyte, such as the solution of an ammonium salt, and the circuit is closed between the carbon and the iron, current will pass in the cell in the direction from iron to carbon. The iron is dissolved, producing double salts of iron and ammonium, out of which hydrates of iron are by and by precipitated by the ammonia generated at the cathodes. But when all the oxygen in the pores of the carbon has been consumed, and when the pores are then filled with electrolyte, the action stops. In order to get a continuous generation of electrical energy from the oxidation of the iron, it is necessary to keep the pores of the carbon open and filled with oxygen. Mr. E. W. Jungner, of Kneippbaden, Norrkoping, Sweden, who is well known by his early work in competition with Mr. Edison in the development of an iron-nickel accumulator, proposes the cell, shown in Fig. 2 for this purpose. The bottom of the vessel B contains an electrode A of iron, and above it, up to the level N, is the solution of the ammonium salt. A second porous clay vessel P within the first contains a solid carbon conductor D and around it small pieces of porous graphite G, saturated with the electrolyte. These pieces are of such a shape and size that the internal spaces between them are not filled with electrolyte by capillary action. The open holes are kept filled with oxygen by a current of air passed through tube R to the bottom of the porous vessel, then rising upward and leaving through tube R_1. Another gas cell described in the same specification is based upon the combination of oxygen and hydrogen gas to form water. (913,300, Feb. 23, 1909.)

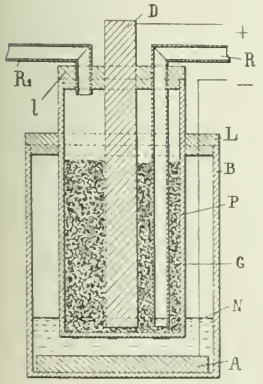


FIG. 2.—GAS CELL.

Metallic Mirrors for Searchlights.—The manufacture of metallic mirrors involves considerable difficulties, since it is not easy to obtain cast or spun metal free from flaws and with a surface which, when highly polished, does not show the grain of the metal. Moreover, for spinning, comparatively thin metal has to be used which is not sufficiently rigid for a mirror of large dimensions. Mr. Sherard Cowper Coles, of London, who has given much attention to this subject, as to other matters in metal deposition, casts the mirror of suitable metal such as iron, brass, gun metal or German silver, or he spins or stamps sheet metal to the desired curvature. The body is then placed in an electrolytic cell wherein a metal such as copper is deposited on the back thereof, until it has obtained the desired thickness to make it rigid. He then places the mirror in another electrolytic cell, where silver, nickel or cobalt or a suitable silver alloy is deposited upon its reflecting surface. The surface of the mirror is then ground and polished. The above operations may be repeated any number of times until a surface is obtained which corresponds to that of glass. Finally, annular or radial bands of gold or other yellow metal may be deposited in order to obtain white and yellow beams which can be well seen both by day and night and also in foggy weather. (915,415, March 16, 1909.)

SYNOPSIS OF PERIODICAL LITERATURE.

Theoretical and Experimental.

Standardization of a Potassium Permanganate Solution.—Cornelis Offerhaus and Ernst H. Fischer (*School of Mines Quarterly*, Vol. XXX, No. 1) call attention to sodium oxalate "Sorensen" as a standard for the potassium permanganate solution; this salt is in Europe already in general use for this purpose and recognized as the only reliable standard for oxidimitry. They compare sodium oxalate "Sorensen" with electrolytic iron, "Burgess," as to their suitability to serve as standards for the permanganate solution and recommend sodium oxalate "Sorensen" as a result of their investigation, pointing out its advantages. They find that also in using Zimmermann-Rhenhardt's method to standardize the $KMnO_4$ solution, sodium oxalate may be used to advantage.

Pyrometer.—A simple form of thermoelectric pyrometer for students' use was exhibited recently by C. R. Darling before the British Physical Society and is described as follows in the (London) *Electrician* of March 12. In this instrument the hot junction of nickel and steel, or iron and constantan, is protected by a mild-steel cap, bored from the solid, and about 6 in. in length. This cap is screwed to an iron barrel of any desired length, and the wires pass from the junction through twin bore fireclay to terminals screwed into a piece of hard fiber. The terminals are made of the same metal as that of the wire attached, and leads of the same wire are taken to a cold junction, kept in oil, and the indicator. The pyrometer is easily put together by the students and is used to form a temperature-scale from the deflections of a galvanometer by insertion in molten metals, or salts of known freezing points. The mild-steel cap resists the action of molten substances far better than porcelain or silica, and enables the junction to follow a changing temperature more rapidly. The errors incidental to the forms in which no provision is made for temperature changes of the cold junction are avoided, and no damage ensues from dropping or rough usage as in the case of pyrometers protected by porcelain or silica. The cap, when worn out,

is readily replaced. At the same time Mr. Darling described the following combined meter-bridge and potentiometer, with a new tapping-key device for pyrometric and general laboratory work. The arrangement of this apparatus is that of an ordinary meter bridge with four gaps, but with four meters of stretched wire, so that one, two, three or four meters of wire may be used in a bridge. Between each pair of wires is placed a groove, through which passes a rod of phosphor-bronze on which the tapping key slides. These rods are connected to a terminal at the side. Hence, it is not necessary to connect directly to the keys. The keys are furnished with two knife edges, and may be depressed onto the wires on either side of the groove in which they slide, thus facilitating the finding of the balance-point. Each wire is furnished with an arrangement for tightening. The apparatus may be used as an ordinary bridge or as a bridge with calibrated wire, it being possible to calibrate any wire by the aid of others. It may also be used for the measurement of the e.m.f. of thermal junctions, constants of cells, etc., and all the ordinary purposes of a stretched wire potentiometer.

Rheostat for Small Electric Furnaces.—A simple rheostat was exhibited by C. R. Darling before the Physical Society of London and is described in the (London) *Electrician* of March 12. The defect of the ordinary carbon-plate rheostat (difficulty of accurate control when consuming a large amount of energy) is overcome in this instrument by the use of four rows of plates, each 2 in square, there being 22 plates in each row. Each set of plates is furnished with a separate adjusting-screw and hence may be kept at different degrees of tightness. By means of simple connecting devices, the plates may be used in series or parallel as desired. This form of rheostat is found to be well adapted for regulating electric tube furnaces and for varying the current to any desired extent during the calibration of instruments, etc.

Industrial Electrochemistry.

Hypochlorite for Sewage Purification.—A recent Faraday Society paper of Dr. S. Rideal dealt with the "application of electrolytic chlorine to sewage purification and deodorization by the 'oxychloride' process." The paper contains an account of an elaborate investigation carried out by the author at Guildford on the use of hypochlorite solutions in sewage treatment. The experiments were made on a fairly large scale on the town sewage at the Corporation Works. This when it emerges from the septic tank is dark colored, more or less tend from the presence of sulphuretted hydrogen, and contains very large numbers of bacteria, some of which are capable of producing disease. By adding a small quantity of a chlorinous liquid the odor is removed, and any nuisance arising from sewage distribution is completely avoided. But the most important feature is that the effluent is rendered harmless, the disease-producing organisms being destroyed. After the publication of the author's first experiments in 1904, the Royal Commission on Sewage Disposal visited Guildford and confirmed the results, further finding that the chlorine treatment did not hinder the subsequent purification in the bacterial coke filters. During 1907 and 1908 Dr Rideal has continued the trials, and finds that the process actually *aids* the purification, first, by causing the filter-beds to mature more rapidly; secondly, by keeping the pipes free from fungus growths; thirdly, by the fact that the avoidance of clogging enables a finer filtering medium to be used, which gives better final effluents. The form of chlorine used was a hypochlorite solution prepared electrolytically. This method of sewage treatment has a great degree of usefulness in preventing the pollution of rivers and in entirely removing aerial nuisance.

Iron and Steel.

Manganese, Iron and Carbon.—F. Wüst, in *Metallurgie* for Jan. 8, gives a summary of present information upon the influence of manganese on the iron-carbon combinations, from the earliest writings in the eighteenth century up to the present. The 47 references given, form a good bibliography of the subject. From this review, Dr. Wüst concludes that our information is still fragmentary and proposed for himself the following questions for investigation:

1. How is the solubility of carbon in melted iron affected by increasing manganese content?

2. What influence does manganese have upon the melting point, and other halt-points, of iron-carbon alloys with high percentages of carbon?

3. What alteration does manganese produce in the structure of high-carbon iron-carbon alloys? Is, in particular, the eutectic point of 4.2 per cent carbon displaced by the presence of manganese? If so, how much? At what manganese content does the perlite point disappear, and what constituent takes its place?

In the experiments, Swedish pig iron and "Goldschmidt" manganese were used with pure sugar carbon. Platinum wire heating furnaces were found unsuited for the experiments because even just above the melting point of the alloys manganese volatilized out of them and alloys the heating wire. This difficulty was overcome by surrounding the alloy by a wrought-iron tube, which intercepted the manganese vapors and thus protected the platinum.

Forty-two alloys were made with carbon 4.3 to 6.9 per cent and manganese 0.06 to 80.45 per cent. The conclusions of the investigation are as follows:

1. Manganese increases the solubility of carbon in such manner that with 50 per cent manganese, if the alloy is rapidly cooled, the compound $(Fe,Mn)^3C$ apears to exist in the alloy.

2. The addition of manganese up to 13 per cent lowers the melting point about 12° C. in spite of carbon having risen over 1 per cent; with 13 per cent more manganese, and carbon also 0.5 per cent higher, the melting point is back at the starting point. With 80 per cent manganese and 2.5 per cent more carbon, the melting point is 125° C. above the starting point.

3. Small quantities of manganese diminish rapidly the perlite point, 2 per cent reducing it 30° C. When over 5 per cent of manganese is present, the perlite point disappears completely.

4. Hysteresis of the perlite point is increased by manganese.

5. Increasing manganese hinders the formation of perlite and facilitates that of troostite and solid solution. When perlite disappears, its place is taken by solid solution of carbide in iron.

6. The eutectic point is displaced, and with 15 per cent of manganese lies at 4.05 per cent carbon instead of at 4.2 per cent, as in manganese-free pig iron.

Ferrosilicon.—In *La Lumière Elec.* of March 6, J. Escard begins an article on the processes used for making ferrosilicon. He first discusses the properties and production of the five definite compounds of iron and silicon; namely, $SiFe_2$, $SiFe_3$, SiFe, Si_2Fe and Si_3Fe.

Aluminium.

Use of Silicates in Its Manufacture.—The expiration of the aluminium process patents and the great increase in output of this metal have given rise to many scientific researches and commercial inquiries. In *Metallurgie* for Jan. 8, Max Moldenhauer discusses the availability of aluminium silicates as raw material for the industry. The inquiry is *apropos;* bauxite is found only in a few places, must be transported long distances, it usually contains some silica, so much that it must be separated out by a costly chemical operation. Aluminium silicates are found almost everywhere, and the separation of the silica from them may quite conceivably not cost more than counterbalances the scarcity and inaccessibility of bauxite.

From several electric-furnace experiments it is concluded that the question has been practically solved. By mixing aluminium silicate with iron ore and reduction carbon, the electric-furnace product is a ferrosilicon and an alumina slag containing only very little silica and iron oxide. The slag is to be pulverized, the globules of ferrosilicon removed by magnetic separators, and the alumina used in the electrolytic pots.

Incidentally Herr Moldenhauer determined the melting point of cryolite and the lowering effected by dissolving alumina in it. His results are:

Cryolite					975° C.
"	plus	5	per	cent	Al^2O^3 955
"	"	10	"	"	" 930
"	"	15	"	"	" 910
"	"	20	"	"	" 880
"	"	25	"	"	" 898
"	"	30	"	"	" 898
"	"	40	"	"	" 898
"	"	50	"	"	" 898

These figures are decidedly below previous results, and need confirmation. They were made with native cryolite and commercial alumina and not with pure materials. These mixtures are, moreover, veritable traps for the unsuspecting experimenter on account of the sur-fusion going down away below their proper freezing points before they begin to set, and then not retreating to the proper settling temperature if the cooling is proceeding too rapidly.

Alloys.

Platinum-Antimony.—K. Friedrich and A. Leroux give in *Metallurgie* of Jan. 8 a careful piece of work. They found, from the melting point curve, a distinct alloy, $PtSb^2$, with 47.5 per cent of platinum melting at a maximum of 1045° C. With increasing platinum, the melting point falls until the eutectic is reached at 75 per cent platinum, melting at the surprisingly low point of 683° C. Above this the melting point rose smoothly to that of platinum, 1775° C. Pt^2Sb^2 possibly forms in the solid alloy, being recognized miscroscopically, but does not show on the melting-point curve.

RECENT METALLURGICAL PATENTS.

Iron and Steel.

Adding Manganese.—Ferromanganese is the most important of all ferroalloys. The addition of ferromanganese to steel is usually effected by throwing large pieces of ferromanganese into the liquid metal immediately before pouring or tapping. But this method has decided drawbacks: a considerable portion of the ferromanganese is retained by the tough layer of slag on the molten metal; further, the temperature of the steel bath is reduced by the solid pieces of ferromanganese; and the manganese is not uniformly distributed throughout the steel bath. According to Mr. Wilhelm Schemmann and Mr. Jegor Brown, of Rombach, Germany, all these disadvantages are avoided if the ferromanganese is melted separately and added in liquid state to the liquid iron. They have devised a special small electric furnace for this purpose, which is described and illustrated elsewhere in this issue in the Analysis of Current Electrochemical Patents (though it would seem that a simple small induction furnace would also do very well just for this purpose). The advantages are that a very uniform distribution of manganese is obtained. Further, a much smaller amount of manganese is required than otherwise. For instance, cross-sections which when the steel was produced by adding ferromanganese in solid form required at least 0.4 per cent maganese, can be easily rolled even if the steel contains only 0.29 per cent manganese, provided the ferromanganese has been added in liquid form. There is, therefore, a double saving, because no manganese is lost in the slag and because the proportion of manganese in the steel can be reduced without impairing its quality. If, for instance, a converter charge of 15 tons of metal is to be finished by the addition of ferromanganese in solid form (taking into consideration that 25 per cent of the manganese added, that is to say, one-third of the manganese remaining in iron, becomes converted into slag) it is necessary for the purpose to use $15{,}000 \times \frac{0.4}{100} \times \frac{4}{3} = 80$ kg of manganese or 100 kg of ferromanganese containing 80 per cent of manganese. If ferromanganese is added in liquid form then for manufacturing a steel of at least the same quality and equally suitable for rolling, it is sufficient to have $15{,}000 \times \frac{0.3}{100} = 45$ kg of manganese or 50 kg of 80 per cent ferromanganese. If the total consumption of ferromanganese in a steel foundry is considered, the saving effected on a large number of charges will be still greater for the following reasons. Ferromanganese of high percentage cannot be stored, as the richer it is in manganese the quicker it is decomposed by the action of the moisture of the air into powder. As the latter is kept back by the slag cover when being thrown into the metal bath, it could not up to now be used at all and formed an inconvenient and expensive waste. If the ferromanganese is first liquefied even the powdered ferromanganese can be melted, so that also in this respect the process according to this invention is advantageous in view of the necessity of having large stores of ferromanganese which cannot be avoided where manufacture is carried on on a large scale. (915,488, March 16, 1909.)

Tin.

Detinning Tin Scrap.—A patent with considerably broad claims for a method of detinning with chlorine has been issued to Messrs. F. von Kügelgen and G. O. Seward. It is assigned to the Tin Products Co. Dry chlorine at a suitably low temperature combines with tin forming stannic chloride, but does not attack iron. Since the reaction evolves heat, care must be taken to keep the temperature sufficiently low, either by cooling the vessel or by limiting the amount of chlorine. At higher temperatures the iron is attacked. But the temperature must be high enough to secure a complete detinning. The first claim refers to "the recovery of tin from tin scrap by treating the latter in a closed vessel with dry chlorine to form stannic chloride, maintaining the temperature sufficiently high to effect complete detinning and controlling the temperature to keep it below that at which iron is attacked." (915,029, March 9, 1909).

Wet Process for Metal Extraction.

Gold, Platinum, Silver, Nickel, Copper.—Mr. A. Seigle, of Lyons, France, patents a wet process for metal extraction which we will describe as applied to the extraction of copper and nickel. The finely ground ore is mixed with quartz sand and placed in a digester fitted with mixing paddles and moistened with a weak solution of calcium and magnesium chlorides (a by-product of the ammonia-soda process) and a small quantity of protochloride of iron is added. The solution must be sufficiently rich in chlorides. When the ore and solution form a well-mixed fluid paste, steam is introduced into the digester at a pressure of 2 kg (42 lb. per square inch) or more, and the pressure is maintained for several hours or a day. The result of the reactions which go on is the formation of compound insoluble silicates of calcium, magnesium, iron, etc., and the formation of soluble chlorides of copper and nickel. (In this way it is possible to get chlorides of copper and nickel free from iron, even from ores containing iron as silicate.) If the ore contains silver, gold and platinum it is advisable to first extract the copper, nickel and silver, but care must be taken to add a sufficient quantity of sodium chloride to the washing solution to dissolve the silver chloride. If the ores or sands are fairly rich in gold or platinum it is sufficient to add some nitrate of soda or certain other nitrates to the chloride solution used for moistening the ore in the digester and to operate as explained before, making use of the combined action of silicic acid and steam under pressure. The "chlorides and nitrates are fairly well decomposed and gold and platinum are easily dissolved in the sort of aqua regia thus formed." For poor auriferous ores, it is better to use the cyanide process, using not potassium cyanide, but potassium ferrocyanide. The result of the combined action of silica, compressed steam and air is the formation of, firstly, a double silicate of potash and protoxide of iron, and, secondly, a double cyanide of potassium

Silicon.

Calcium-Silicon.—In the June issue of last year (Vol. VI, p. 241) Dr. Hans Goldschmidt discussed the use of calcium silicide in the production of metals, especially steel. In this connection a recent patent of Dr. Goldschmidt is interesting as it describes a method of making an alloy of silicon and calcium free from carbon. Alloys of silicon with barium or strontium may be made by this method. A mixture of two parts by weight of silica is mixed with one part by weight of coarse coal with a suitable flux to produce a slag which crumbles. A convenient flux is fluoride of calcium which is mixed with chloride of calcium in the proportion of 15 parts of the former to 5 parts of the latter, and this mixture is added to 100 parts of the lime and silicon mixture. The mixture is heated in an electric furnace, yielding a calcium-silicon alloy containing 40 parts by weight of calcium and 60 parts by weight of silicon, if practically pure silicon is used. Instead of silicon, ferro-silicon may be used, and instead of lime, carbonate of lime or any salt of calcium which produces lime when being heated. The calcium-silicon alloy thus produced is free from carbon. As the slag crumbles on cooling, instead of forming a solid slag, the light grains of the alloy can be easily separated from the slag by screening. (015,172, March 16.)

Electric Furnace Leads.

An interesting phase of the development of the electric furnace is presented in the solution of the problem of making a good connection between the cables and the electrodes. Owing to the high temperatures prevalent in operation, soldered joints are out of the question.

Messrs. Dossert & Company, of New York City, have perfected a type of solderless connector which is admirably adapted to meet the exigencies of the electric furnace. The accompanying

ELECTRODE CONNECTION FOR FURNACE.

illustration shows a Dossert lug made for the equipment of the furnaces of the Susquehanna Smelting Company, of Lock Port, N. Y.

The cables are 2,000,000 circular mils, with a capacity of 30,000 amperes. The furnace leads enter the Dossert lugs by means of a compression sleeve held within a compression nut which screws up on the nipple end of the lug, clutching the cable with a tight grip and affording perfect contact. No solder is used, and, in addition to being exempt from the troubles incident to melting of soldered connections, the Dossert joint requires only a few minutes' time to be connected or disconnected, and will not injury to either the connector or the cable.

The Use of Pyrometers in Various Industries.

An interesting 30-page pamphlet in German on the use of pyrometers in various metallurgical and chemical industries has been issued by the Siemens & Halske Co. It discusses the adaptability of different types of pyrometers—thermoelectric, electric resistance and optical pyrometers—in different industries. While the pamphlet contains considerable details on pyrometer installations, we will give in the following abstract only the chief recommendations which are made in the pamphlet.

Blast Furnaces.—To measure the temperature of the blast, thermoelectric pyrometers with a platinum, platinum-rhodium couple are recommended. Since the temperature does not rise above 900° C., a platinum, platinum-iridium couple could be used, but a platinum, platinum-rhodium couple is preferable, since it can be made more reliable so as to remain accurate for a very long period of use. To protect the couple a double tube of fused quartz with iron tube and a cast-iron cooling head is recommended. It is important to take into consideration a possible variation of temperature of the "cold junction," but with the aid of the "cooling head" this variation of temperature can be reduced to a permissible minimum. The instrument, which gives the temperature, is preferably built as a recording instrument. If several thermocouples are connected to the same recorder, the automatic switch, described on page 135 of our last issue, is recommended.

Foundries.—While the skilled foundry foreman formerly relied on his eye to estimate the correct temperature of casting, the optical pyrometer is more reliable and cheaper, since less expensive help can be employed. The temperature of casting must, of course, be known. The incandescent lamp of the pyrometer is adjusted to this temperature and as soon as the observation of the molten metal surface shows that it has assumed the correct temperature, casting begins. The pyrometer is placed at a distance of about 2 m (6½ ft.).

Annealing and Hardening Furnaces.—In simple gas furnaces a thermo-electric pyrometer with indicating instrument is most convenient. In larger furnaces it may be important to determine the temperature of certain special pieces which are being heated. This can best be done by means of an optical pyrometer through a peep hole in the door. For hardening furnaces (gas-fired muffle furnaces, fused lead bath, electrically fused barium chloride bath) the thermoelectric pyrometer is used with indicating instrument.

Tempering Furnaces.—Here again the thermo-electric pyrometer is most convenient. In case of a series of tempering furnaces five of them, with their thermocouples, are connected to one recording instrument with automatic switch.

Boilers.—To control the temperature of the flue gases, platinum, platinum-iridium couples with indicating or recording instrument are recommended. If for special reasons the temperature in a steam pipe is to be measured, a copper-constantan thermocouple (which can be used up to 500° C. or 932° Fahr.) is screwed into the pipe.

Porcelain Stoneware Factories.—In view of the large space of the furnaces the optical pyrometer is in general most suitable as it permits to determine easily the temperature at any desired place within the furnace. If a furnace is always charged with the same material, as is often the case in stoneware factories, a platinum, platinum-rhodium thermoelectric pyrometer with recording instrument is most useful. In this case a standard temperature curve, showing the variation of temperature during one firing operation, is plotted as the result of a number of successful runs and all following runs are adjusted according to this temperature curve.

Chemical Works.—In sulphuric-acid works the temperature in the lead chambers is best controlled by means of electric resistance pyrometers. A number of these are connected to an indicating instrument for use of the foreman, while a recording instrument is placed in the superintendent's office.

Glass Works.—In glass manufacture both thermo-electric and optical pyrometers are employed as follows: For the melting furnace the platinum, platinum-rhodium thermo-element with indicating or recording instrument; for determining the tempera-

ture of casting the optical pyrometer, and for the cooling furnace, the platinum, platinum-iridium thermo-element with indicating or recording instrument.

Further details concerning the pyrometers made by the Siemens & Halske Co. may be obtained from this company itself at 50 Church Street, New York City, or by their sole agent, Mr Charles Engelhard, 32 Cortlandt Street, New York City

Induction Furnaces.

While we have kept our readers fully informed of all advances in recent years in the construction, design and applications of electric induction furnaces, a concise summary of the present state of the design should be welcome.

Induction furnaces are now made in two distinct types First, the simple induction furnace, as invented by Mr. F. A. Colby, of this country, and Dr. Kjellin, of Sweden, and second, the "combination furnace," a combination of the induction principle with electrodes, invented by Messrs. Roechling and Rodenhauser, of Germany. Both types of furnaces are built in this country by the American Electric Furnace Co., of New York City.

The simple induction furnace consists of an annular hearth lined with magnesite, through the center of which passes one leg of a transformer, around which the primary coil is placed The primary coil is connected to the terminals of a single phase alternator or transformer, and the alternating current in the primary induces a low voltage high amperage current in the annular hearth. The arrangement is equivalent to a transformer with a single secondary turn (the annular hearth) The amperes in the annular hearth are, therefore, approximately equal to the amperes in the primary circuit, multiplied by the number of primary turns.

The combination furnace consists of the same arrangement, but in addition has a number of steel terminal plates embedded in the lining, which are connected to a few heavy turns of copper placed outside the primary coils, which collect and feed to the terminal plates the induced current in these turns. The

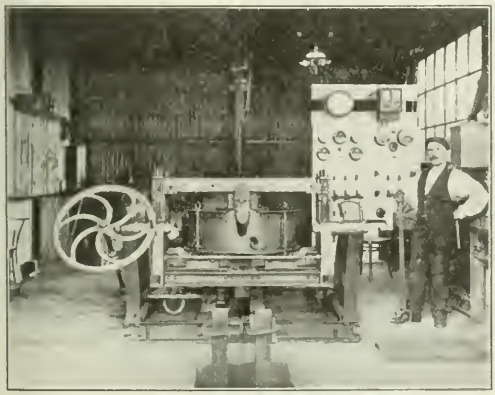


FIG. 1.—60-KW SIMPLE INDUCTION FURNACE FOR STEEL, BRASS BRONZE OR ALLOYS.

close proximity to the primary coil and to the magnet core of these auxiliary turns tends to suppress magnetic leakage which, in a large, simple induction furnace may be very considerable It follows, therefore, that for large-size simple induction furnaces an unusually low frequency must be used to avoid a poor power factor. Owing to the above-mentioned arrangement of secondary turns and terminal plates, the combination furnace can be built up to a large size and still work with currents of normal frequency and show a good power factor A high primary voltage may be used, so that it is possible in most cases to use central station power and avoid the expense of installing expensive generating plant.

The terminal plates, being protected by the lining which here acts as a "conductor of the second class," do not come in contact with the molten bath, and therefore can be used for an indefinite length of time.

The combination furnace can be run either on a single or

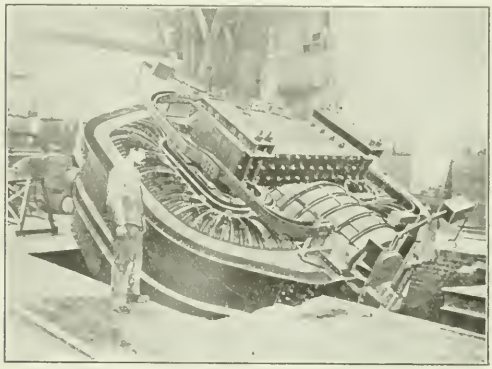


FIG. 2—TILTING AN 8-TON COMBINATION FURNACE.

three phase circuit, but as a general rule is built on the three-phase system, as a power plant for this class of current is less expensive to build and easier to regulate, besides being more convenient for general power distribution. Further details of the design of the Roechling Rodenhauser combination furnace may be found in our Vol. VI, pages 10 and 458.

These two types of furnaces have each their own uses and advantages. The simple induction furnace is primarily a melting furnace and can be used to the best advantage in melting high-quality material which needs little or no refining. It is used commercially as a substitute for pot melting and produces extremely high-class steel. In one important direction it has a great advantage over the ordinary crucible, namely, that a high and easily controlled temperature is obtainable. Readings of 1700 to 1800 C have been obtained, and, as the temperature is directly dependent upon the primary current, it follows that the regulation is very simple

Among other advantages of this type of furnace for melting steel is the economy in labor over ordinary pot melting. Three men and a boy per shift can easily handle a furnace capable of producing 1000 tons of tool steel per year

The whole process is clean, the material to be melted is not affected in any way by the method of heating, no gas can injure the steel, and "overkilling" is practically impossible.

The combination furnace is intended for such cases where an efficient refining operation is required. It is constructed in such a way that slags are easily worked in a roomy and accessible central hearth Hot metal taken from the converter, open-hearth furnace or gas-fired mixer can be treated, and a large daily output of highly refined material produced.

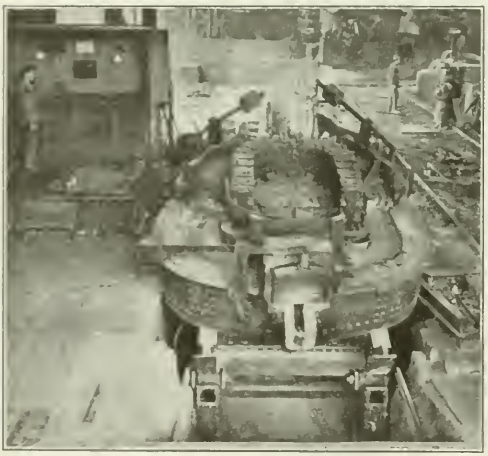
The finished product is made into rails, axle or tire blooms or tool steel in accordance with the degree of refining carried on

In the case of the simple induction furnace the charge introduced into the furnace may be either in the hot molten state or in the form of cold scrap, pig iron, etc As already explained, the action of the furnace depends upon a complete ring of metal being obtained in the hearth, and it is obvious that this result is most readily attained by pouring in molten metal which can flow round the annular hearth and complete the

[illegible] is added in this molten condition, naturally a saving is effected in time and power during the treatment in the furnace. However, in the simple induction furnace, it is more usual to charge with cold materials, and in this case it is necessary to have one or more metal rings in the hearth when starting up the furnace. The rings may be of cast or wrought iron, as most convenient, and the current is turned on until they melt down. The charge is gradually added and rapidly melts down until the required full charge is complete. The temperature is now raised to any desired degree, and the necessary additions made for correction of carbon, manganese, chrome, tungsten, etc., according to the class of steel to be produced.

The furnace, built on a tilting frame, is teemed into the ladle. Where cold materials are charged, about one-third of the total furnace contents is retained in the hearth, in order to secure continuous operation of the furnace.

Another use for this type of furnace has been found in melting and preparing brass and similar alloys. For this purpose a special crucible has been devised, the material of which



[illegible]—ON THREE PHASE COMBINATION FURNACE.

is to some extent a conductor of the electric current. In this case, the primary coil is so arranged that the crucible can be heated directly up to the melting point of the metal, thus avoiding the necessity of starting up by means of an initial molten charge or cold rings.

Other advantages of this method are that the crucible can be more thoroughly emptied at each melt, and recharged with cold metal, and that it is possible to shut down the plant entirely at night, without fear of damaging the lining.

Whereas the use of the plain induction furnace is thus necessarily confined to high-grade steels, brass and bronze, the combination furnace is particularly adapted for treating and producing steel in large quantities.

Under ordinary conditions the side channels, forming the induction part of the furnace, are very little affected by slag corrosion, being so arranged that no slag can enter this portion of the bath. Therefore, only the central part of the working hearth [illegible] has to be renewed at intervals.

The terminal plates are covered with lining material stamped in a similar way.

The furnace is started up in the first instance in a manner similar to that used for the simple induction type, and hot metal is added as soon as the lining is burned in.

The lining consists of dolomite mixed with a proportion of coal tar, the whole forming a plastic mass, which is heated and stamped in by means of hot rammers.

The metallurgical reactions are similar to open-hearth practice.

The power consumption varies in direct proportion to the degree of refining considered desirable. It also depends to some extent upon the size of the furnace, as a large furnace loses less in radiation than a small one. As a general rule, it may be stated that the thermal efficiency varies from 55 per cent to 68 per cent.

In the following we give a list of the types and sizes of furnaces, as now built commercially, with interesting data on power consumption, frequency, power factor, etc., according to the claims of the manufacturers:

Contents in tons.	Maximum power in kw.	Power to keep furnace hot.	Power factor.	Periods.
0.1 to 0.15, simple induction...	60	25	0.76	60
0.5 to 0.75, combination.....	100	30	0.85	50
0.8, simple induction.....	150	40	0.70	25
1, combination.....	175	50	0.80	50
1.5, combination.....	275	80	0.70	50
1.6, simple induction	225	75	0.65	16
2.5, simple induction.....	350	310	0.38	14
3, combination.....	350	100	0.60	50
3 to 3.5, combination.....	350	100	0.80	25
5, combination.....	550	165	0.65	25
7, combination.....	700	210	0.60	25

The last mentioned biggest 7-ton combination furnace is claimed to produce daily 140 tons for rails and 63 tons for high-grade steels. If it is charged with molten converter steel, the latter containing 0.08 P., 0.08 S., 0.5 Mn., 0.1 C., the steel is refined in the electric furnace to steel for rails containing 0.05 P., 0.04 S., 0.8 Mn., 0.5 C., with a power consumption of 100 kw-hours per ton. The same converter steel is refined to high-quality steel containing only traces of P. and S. and 0.2 Mn., 0.5 C., with a power consumption of 250 kw-hours per ton.

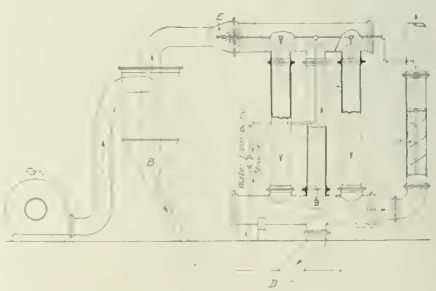
With the same electric furnace, when charged with molten open-hearth steel, the daily production is 70 tons.

The analysis of the electric steel rails made by the Roechlingsche Eisen und Stahlwerke for the Prussian State Railways is 0.75 C., 0.10 Si., 0.67 Mn., 0.044 S. and 0.023 P.

Collecting Precious Metal Dust.

Various means have been devised for collecting or reclaiming the precious metal dust in mills crushing and treating the ores dry, and the following application of the Koerting spray nozzle and dust collector will be found interesting in this connection.

The below illustration shows one of the exhaust fans ex-



COLLECTOR OF PRECIOUS METAL DUST.

hausting the dust from the mill and discharging the same through a pipe to the air separator *B*. The heavy metal discharge into this separator drops to the bottom and then spouts down to proper machine for treatment.

The separator *B* does its work quite satisfactorily, as far as

it goes, but does not take care of a large quantity of very valuable dust, which sometimes goes to waste for lack of the proper apparatus or method of reclaiming it. In quite a number of cases this dust contains some of the richest values in the ore and in some instances weighs as much as 135 lb. per cubic foot and contains from 20 to 30 per cent of the valuable metals.

The dust collector is made of suitable metal according to requirements, and is equipped with a sufficient number of spray nozzles of special construction through which water under about 50-lb. pressure is forced.

The ore dust is forced by the blower and enters at *E*, and in passing up and down the different compartments is absorbed by the water discharged through the spray nozzles containing a spiral, which imparts to the water a rotary motion. This has the effect that on issuing the water is torn into a very fine spray which completely fills the different dust-collector pipes in which nozzles are installed; therefore as the dust passes through the sprays it is thoroughly saturated with water, drops to the bottom of dust collector, and its deposition in sealed tank *D* is made certain.

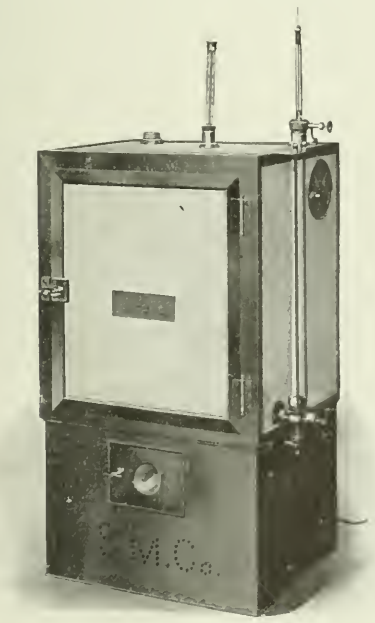
Of course, in the steel tank sufficient water is added to make a wet pulp so that it will easily run to the table vanner below.

To be absolutely sure that none of the valuable dust escapes with the surplus air at the air outlet *S* of dust collector, a sheet-iron spiral, as shown in the illustration, is installed, and above this spiral is also installed another spray nozzle.

The spray nozzles and dust collector referred to above are manufactured by the Schutte & Koerting Company, of Philadelphia, Pa.

Electrically Heated Incubator for Laboratories.

There is probably no place in scientific work where as fine an adjustment of heat is required as in the bacteriological in-



ELECTRICALLY HEATED INCUBATOR

cubator and the work has been carried on for a long time under difficulties with the old-style gas-heated ovens.

The problem has been solved by using electricity for both the heating and the regulation, by the Scientific Materials Company, of Pittsburgh, Pa., and the oven, developed and patented by this company, is an interesting example of the possibilities of controlling electrically generated heat with utmost exactness.

The incubator consists of a three-wall oven, made of heavy copper, which provides a water jacket and an air space entirely surrounding the oven, and is thoroughly insulated with heavy asbestos board, which is finished in white enamel.

The desired temperature (37 2/5 deg. C.) is maintained by means of incandescent lamps in the base, which are controlled by a make-and-break device which is in turn operated by a new mercury regulator. By this arrangement the temperature can be maintained within a small fraction of 1 deg.; in fact, a 45-days' continuous test, made by Prof. H. E. Lowe, of the Carnegie Technical Schools, showed that the variation of temperature in this time was hardly perceptible.

Another feature of the apparatus is that it does away with the open flame, heretofore used for heating, thus eliminating the great liability of fire, as the operation is continued without interruption night and day.

In the water laboratories, an incubator is required which will maintain a constant temperature of 20 deg. C. and the electric incubator is answering this purpose admirably at the water purification plant of the city of McKeesport, Pa., where it is set up in an ice-box, wherein the temperature is kept below this point.

After experiments covering more than four years the inventors have a most simple and durable arrangement, which can be adjusted by the operator and can be used on any ordinary lighting circuit, either alternating or direct.

Washing and Coking of Coals.

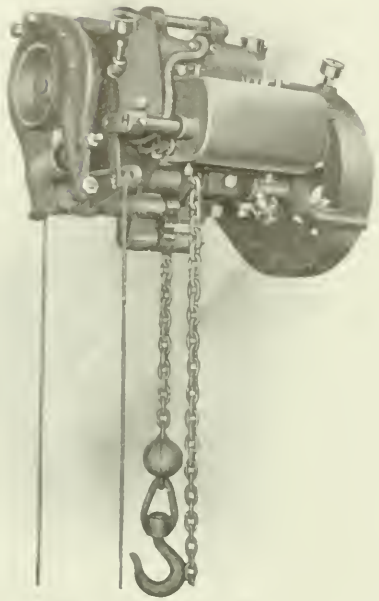
Investigations conducted at the fuel-testing plant of the United States Geological Survey at Denver, Col., during the fiscal year 1908 into the washing and coking of the coals of the Rocky Mountain region have just been reported upon by the Survey.

Of 37 coals tested from the Rocky Mountain region all but three produced good coke under proper treatment, though a number of them had been considered non-coking.

A bulletin detailing the tests conducted at the Denver plant by A. W. Belden, G. R. Delamater and J. W. Groves has just been issued by the technologic branch of the Geological Survey. In this bulletin the following general statement is made by Mr. Belden:

"The washing tests of coal were made to determine the possibility of so improving the quality of the coal as to render it available for the production of coke—for the coal used in coking must be as free as possible from ash, sulphur and other impurities, because of its prospective use in metallurgical processes. The coking tests were made to determine the possibility of utilizing the various coals in this way or to devise improvements in coking practice. The washing tests have already demonstrated the fact that many coals which are too high in ash and sulphur for economical use under the steam boiler or for coking may be rendered of commercial value by proper treatment in the washery. The coking tests have demonstrated that many coals which were not supposed to be of economical value for coking purposes may be rendered so by proper treatment in the washery and coke oven. Of more than 100 coals from the Mississippi Valley and the Eastern States some of them regarded as non-coking, which had been tested at St. Louis in 1906 all except six had been found, when carefully manipulated, to make fairly good coke for foundry and other metallurgical purposes, and similar results with Western coals have been now obtained at Denver. The tests detailed in this bulletin are a continuation of the work started several years ago in St. Louis at the government fuel-testing plant there."

One-Half Ton Hoist.



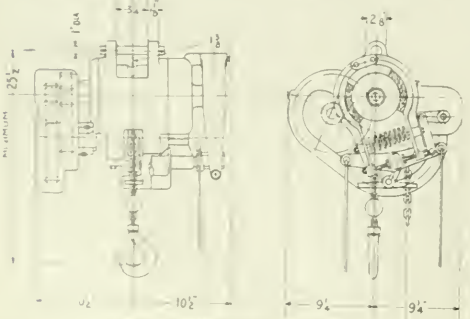
CUT No. 1.—ONE-HALF TON HOIST.

Without load it weighs 230 lb. and it is 25" in high, 21" wide, and 18½" thick.

The motor is wound for 115, 230 or 500 volts, direct current, is fully enclosed and dust and weatherproof.

The load is hitched by a chain and pocket wheel, the speed reduction for the pocket wheel consisting of a double reduction train of spur gears protected by casings. The gears are cut from solid blanks and all lubrication is by grease fed through compression cups.

Grease lubrication is in every way superior to oil for hoist



CUT No. 2.—DIMENSIONS OF HOIST.

gearing, because it is cleaner, does not drip and there is no danger of it getting into the armature or commutator.

The capacity of the S-7 hoist is heavy enough to permit of its installation in machine shops, tool rooms in the machine shop, or its general use in artificial ice plants and industrial establishments where the erection of a comprehensive runway system is impossible, either on account of first cost or because the buildings are not strong enough to support a long runway. In such cases light jibs can be placed at points where the loads are stored, the hoist and carriage running back and forward on the boom. These jibs are very inexpensive and can be attached to a building column if it is available or supplied with a mast, making them entirely independent of the building for support.

In small power stations and boiler rooms they are extremely convenient to aid in the disposal of ashes and in carrying coal to the furnaces, and in shipping rooms they can be used to load trucks with light packages, greatly economizing labor.

The amount of headroom taken up compares very favorably with a chain block of equivalent capacity, for which it may be substituted, thereby making a large saving in labor charges. The hoisting speed of the electric hoist is many times greater than the fastest speed possible with a chain block.

Cut No. 1 shows the appearance of this device, and on cut No. 2 are marked the overall dimensions.

Increase in Use of Wood Preservatives.

An increase from 3,500,000 gal. of the oil of coal tar, or creosote, imported into the City of New York in 1904, to an amount estimated to be almost 25,000,000 gal. last year, is one of the indications pointing to the progress of the movement for the conservation of forest resources.

It is creosote which the government and scores of corporations and private wood users have found to be one of the most satisfactory preservatives of railroad ties, mine props, telephone and telegraph poles, fence posts, and for timbers used for other commercial purposes.

Formerly the production of creosote, from both coal tar and wood tar, far exceeded any demand for wood-treating purposes. However, the number of wood preserving plants has grown so rapidly within the last four years that this country is not now able to supply its own demand for coal-tar creosote.

This year has started most auspiciously; during a five-weeks' period in December and January the importation through New York alone was 15,000 tons, giving a weekly average of 3000 tons, or 68,000 gal. It is significant that during this same period the importation of related by-products from coal kept pace with that of creosote. Ammonium carbonate, chloride, sulphate and sal ammoniac entered to the amount of 104, 227, 1260 and 400 tons, respectively. If these had been all made into the sulphate, the equivalent product would have been 460 tons per week. The estimated ratio of 20 lb. of sulphate to 1½ gal. of creosote oil would make an equivalent production of 69,000 gal. of creosote. This is not far different from the 68,000 gal. which were really imported. Since these ammonia products and creosote are being imported in this relation, it is plainly evident that the production of creosote is not alone deficient, but also coal-tar products in general.

The production of creosote in this country will, in all probability, continue to be far less than the consumption. The wood preservation industry has been in its infancy only, and enormous demands may be expected in the future. The coke, and consequently the coal-tar industries, have until recently been at their best, but even at their best the supply of by-products has run short. On this account we should turn to the other sources to supply the increasing demands for creosote preservatives.

A great help may be eventually afforded by the increasing use of wood-tar creosote, which has not been in high favor in the past. Within the last few years some of the more important wood distillers have been turning into a profit those oils and tars which were formerly run to waste. The demand for these products is increasing, and this recovered by-product has been asserted to be not only a revenue for the producer, but also a valuable preservative for the treatment of structural timber.

Engineering Books in Public Libraries.

The more progressive city libraries of the country are paying increased attention to engineering and technical subjects in their work with the public. Among those which are especially active in this field is the Public Library of Washington, D. C., as shown by the annual report for 1907-08, just issued. This institution has organized a special department, the Useful Arts Department, to meet the demands of its readers for books on the engineering branches, trades and handicrafts, business and industries in general. Here on open shelves are placed about 6000 well-selected volumes, purchased very largely within the last three years and many of them expensive. Over 160 periodicals are received, which include nearly all the important American publications and some foreign. On the subject of electricity alone, for example, 12 periodicals are received.

All these periodicals, both current and back numbers, are freely accessible. All but current numbers are issued for home use. Various engineering indexes make their contents accessible.

An important feature of the room is the collection of trade catalogs issued by manufacturers. These catalogs are classified and arranged by subjects on open shelves and are indexed by firms. This feature, according to the report, is much appreciated by patrons of the room. Manufacturers and others in distributing advertising literature would do well to keep this library in mind.

Notes.

The University of Missouri, School of Mines and Metallurgy, Rolla, Mo., announces a six-weeks' summer school, beginning June 14, 1909, for mining students, mine managers and superintendents, graduates and undergraduates of engineering schools, etc. The courses include fire assaying, qualitative chemical analysis, quantitative chemical analysis, mineralogy, metallurgical laboratory work and a course in mining.

The **Wisconsin Section** of the American Electrochemical Society held a meeting on March 1 in the Chemical Engineering Building of the University of Wisconsin. Dr. O. P. Watts presented a paper on "The Improved Quality of Electrolytically Deposited Metals Caused by the Addition of Certain Foreign Substances to the Electrolyte." In the discussion which followed the paper, the influence of a concentrated film of non-conducting colloid or other inert foreign substance at the surface of the cathode was considered.

Nitric Acid from the Atmosphere.—The Gesellschaft für Sauerstoff und Stickstoff Industrie (German Society for the Oxygen and Nitrogen Industries, secretary, J. W. Haeussler, Berlin, W. 62 Kurfurstenstr. 89) held a meeting on Feb. 10 in the Institute of Technology at Charlottenburg. Regierungsrat Kolbe was in the chair, and Professor Erdmann lectured on the fixation of atmospheric nitrogen in its technical and industrial aspects.

The **Ore Dressing Machinery Co.,** 114 Liberty Street, New York City, has just issued a well-illustrated pamphlet on the Hennig ore concentrator which we described in our January issue, page 42.

Messrs. **C. W. Leavitt & Co.** have removed their offices to the Hudson Terminal (Cortlandt Building), 30 Church Street, New York City.

Thermit.—The Goldschmidt Thermit Co., of New York City, has issued a revised and enlarged edition of their "Instructions for the Use of Thermit in Railroad Shops," giving concise and exact rules on the application of the thermit process for repairs of steel castings. Besides much useful technical information, the pamphlet contains many interesting and instructive illustrations.

Silico-Manganese.—We have received a report by Mr. A. Campion, analytical and consulting chemist, of Glasgow, on the use of silico-manganese as a substitute for ferrosilicon. In view of some accidents which recently occurred as a result of ferrosilicon shipped on board ship giving off poisonous gases, it is pointed out that silico-manganese is absolutely harmless under similar conditions. It can be stored or shipped without fear of explosion or poisoning, as it gives off no noxious gases. The use of silico manganese instead of the combined use of corresponding quantities of ferrosilicon and ferromanganese has also certain advantages in the steel industry. Messrs. Roberts, Evans & Woodhead, of Liverpool, England, are the manufacturers of silico-manganese.

Electroplating and Storage Batteries.—The (London) *Electrician* of March 12 contains the following note: "It has been realized for some time past in the electroplating industry that the quality of the work is dependent upon steadiness of the electric current, the slightest variation affecting the density and evenness of the deposit. The D. P. Battery Co., of Bakewell, has recently laid down a battery with unusually large-size cells for a Midland firm. This has effected so marked an improvement in their manufacture that there seems little doubt that the use of accumulators, instead of plating direct from the dynamo, will ultimately become more or less general."

Perforated Metal.—The bulletin No. 1425, issued by the Allis-Chalmers Co., under the title "Perforated Metal," contains illustrations showing some of the varieties of perforated plates now commercially available. Perforated metal is considered to be superior to wire cloth in being much stronger, more uniform in size of hole or mesh and less liable to tear or rust out. Unlike wire cloth, it presents a perfectly smooth surface, allowing the material to pass it smoothly and quickly. It is not as liable to become clogged, making it more satisfactory for sizing, graining and separating. The Allis-Chalmers Co. rolls plates to exact diameter of cylinder and makes cylinders to order as well as revolving screens for stone, grain, coal, etc.

Producer Gas from Peat.—According to the *Chemical Trade Journal* of Jan. 23, the Power-Gas Corporation, Ltd., who are exploiting Dr. Mond's patents in England, have been experimenting for many years past to apply the Mond process to the gasification of peat, and that success has marked their endeavors is shown by the fact that three installations are either already in operation or nearly completed—one in Norfolk, one in Italy, the third one at Mont Cenis Colliery in Westphalia, Germany—and it is expected that data as to regular running results will be published shortly. In the last-mentioned plant large practical trials of peat have been carried out by the officials of the Power Gas Corporation, the following results having been obtained. The peat used in these trials contained from 40 to 60 per cent moisture, and from each ton of peat calculated as theoretically dry (containing 1 per cent nitrogen) there was produced 32 kilos of sulphate of ammonia together with 240 cu. m. of good power gas, and, generally speaking, the results of this process are that 71 to 75 per cent of the nitrogen in the peat is recovered in the form of sulphate of ammonia together with 80,000 to 85,000 cu. ft. of good power gas (150 B.t.u. per cubic foot) per ton of dry peat gasified. Messrs. Frank & Caro, of calcium cyanamide fame, are engineers as consulting chemists with the German Mond Gas Co.

Tellurides.—Because some of the best gold ores of America are tellurides, a recent publication of the University of Wisconsin, entitled "A Study of Tellurides," by Dr. Charles Alvin Tibbals, Jr., is of particular interest. Mr. Tibbals received the degree of Ph.D. at the University of Wisconsin in 1908 and is now assistant professor of chemistry at the Armour Institute of Technology, in Chicago. He has made a thorough study of the general field of artificial tellurides. His work forms a part of the detailed study of tellurium carried on at the University of Wisconsin under Prof. Victor Lenher for the past 11 years on the chemistry of telluride ores.

Gas Engines is the title of Bulletin No. 1063, issued by the Allis Chalmers Company, which is the largest builder of gas engines in the world and has equipped some of the largest gas-engine plants now in operation. This bulletin was issued

for the express purpose of exploiting the vast fields of power service to gas engines and the economies afforded by their application of either producer gas, natural gas, or blast-furnace or coke-oven gas. Although natural gas and furnace gas are not always available, producer gas can be made from almost anything that will burn and such coals as lignite, slack and leaf, that cannot be used under boilers in the production of steam have been profitably utilized in a gas producer and gas engine. Lignite beds underlying from 20,000,000 to 30,000,000 acres of public land, heretofore supposed to be practically useless, are now shown to have a large value for power development. As fuel is ordinarily used for light, heat and power, the losses are so great that, of the total calorific value of the coal, less than 5 per cent on an average is converted into useful work, while the largest and best power stations utilize only about 10 per cent. With the gas-engine-driven units, however, fuel economy is the distinguishing characteristic, resulting in a delivery at the engine shaft of not less than 15 to 20 per cent of the energy contained in the fuel.

Copper Ore.—The well-known firm of ore and metal shippers, the Société Maritime & Commerciale, Antwerp, Belgium, have appointed C. W. Leavitt & Co., New York, as their selling agents in America for their iron and copper pyrites, copper precipitate, copper matte, manganese ore, etc.

European Zinc Trust.—According to a recent consular report an international agreement has been concluded between a number of prominent zinc works, resulting in the organization of what is designated as the "Syndicate des Usines à Zinc." The limit of production of each one of the firms having been established, the principal clause of the agreement stipulates that should the current price of zinc fall below £19 ($92.46), or should the accumulation of stocks show an unusual increase, the limit of production will be proportionately reduced. If, on the other hand, the current price of zinc continues to be above £19, this limit of production may be increased as arranged in virtue of an agreement between delegates from each group of concerns making up the trust, which includes German, Belgian and English concerns, although it seems that agreements have not yet been concluded with the last mentioned. It is asserted that the Giesche works, which produce one-fifth of the total output of zinc in Silesia, is not included in the new combine, whose main object is to regulate production, but competition from this quarter apparently is not feared. Steps have been taken to induce the five most important zinc works in England to join the trust, as to the zinc works of the United States, it is believed that anything like extensive exports of zinc from that part of the world are too far in the future to meet serious consideration at the present time. It is rumored that one of the earliest results of the formation of this trust will be an increase in the present price of zinc, such an advance having already been definitely decided upon. It is further reported that the organization of the syndicate composed mainly of German zinc manufacturers was concluded the latter part of February under the form of a limited liability company. The capital is said to be $509,400, and the management is placed in the hands of Director-General Loh, of the Hohenlohe Works. The sale of zinc will be effected through the agency of Beer, Sonheimer & Co., the Metall Gesellschaft of Frankfort-on-the-Main, and by Aron Hirsch, of Halberstadt. It is stated that this new combine also includes a large number of Belgian, French, Dutch and Austrian works.

Digest of U. S. Patents

Compiled by Symmes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC FURNACES (*Continued*).

No. 588,267, Aug. 17, 1897, Guillaume De Chalmot, of Leaksville, N. C.

Arc type. This furnace, which is especially designed for treating phosphate rock, consists of a brick structure which may be lined with carbon. The hearth of the smelting chamber is a horizontal iron plate, covered with carbon and serving as one electrode. The other electrode is a depending carbon block built up of slabs or square bars, adjustable through a hole in the roof. It may be enclosed by an iron casing above the roof, to exclude air. At one side of the furnace-chamber is an outlet, through which the molten product may overflow. A flue leads from the other side over trays to a stack. A stream of heated air may be supplied to the outgoing fumes. The molten phosphate rock flows continuously from the furnace onto a horizontal iron drum, which is hollow and may be cooled by radiation, currents of air, or by playing water on it by a hose. Sand is sprinkled onto both the descending and ascending sides of the cylinder, the molten phosphate thus flowing onto a coating of sand and being subsequently sprinkled with sand. Sand may be fed into the furnace with the ground or broken rock, and sand may be fed onto the receiving cylinder together with the molten phosphate. Beneath the cylinder is a tank containing water to receive the solidified phosphate. The tank is pivoted to dump the material onto a grating beneath. The wall of the furnace containing the overflow-passage may be built of phosphate rock, and the position of the opening may be varied in height by increasing or decreasing the temperature in the furnace-chamber, thus partly melting away the wall or, reversely, allowing it to build up by solidified product. The fumes from the furnace chamber may be carried over crushed phosphate rock, lime, or water, placed in the trays, to take up the anhydrous phosphoric acid. The air entering the flue oxydizes the fumes.

No. 588,268, Aug. 17, 1897, Guillaume De Chalmot, of Leaksville, N. C.

Arc type. This furnace, mounted on wheels serves as one electrode, receiving a depending carbon electrode. The pot may be lined, or the refractory charge may afford sufficient protection. A layer of carbon is placed in the bottom in starting. The pot may be lined with fire brick and then with carbon, or directly with carbon. The sides and bottom may be in different sections and of different materials. The pot is reciprocated, rotated, or otherwise shaken or jarred, to feed the charge into the arc and beneath the depending electrode. "With an ordinary arc-furnace only the outer margin of the area of the arc is fully effective, since the material to be reduced cannot be introduced beneath the pencil far enough to completely fill the arc, but will only fall in so far as corresponds to its natural or characteristic slope." "The most effective utilization of an arc in electric smelting is only to be attained by filling the entire area in which the arc exists with the material to be smelted and feeding this material in throughout this area as fast as the previously introduced material becomes fused and reduced or fully smelted." The pot may be reciprocated from two to four inches on a track, from five to thirty times a minute, shaking the material down, spreading it out to a considerable distance beneath the lower end of the pencil, and effecting a more thorough distribution of the material to be smelted over the area of the arc. The reciprocation may be effected by a conducting bar connected at one end to the pot by a pin and clamp and at the other end to a pitman. The bar may be connected to one of the electric mains by a flexible cable or zigzag plate.

The bar may advantageously consist of a plate of copper and plate of iron. The holder for the upper carbon has a dovetail groove receiving the upper ends of a number of adjacent carbon slabs which taper downward, removable iron strips extending between the holder and the carbon ends. The holder is carried by an adjustable bar consisting of a strip of copper and two outer strips of iron, being dovetailed at its lower end into the carbon-holder. The pot may be shaken by mounting it on an oscillating shaft either central or eccentric, or it may be mounted to turn on a horizontal axis.

No. 588,267, Aug. 17, 1897, Guillaume De Chalmot, of Leaksville, N. C.

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NEW BOOKS.

Heat Energy and Fuels: Pyrometry, Combustion, Analysis of Fuels and Manufacture of Charcoal, Coke and Fuel Gases. By Hanns v. Juptner. Translated by Oskar Nagel, N. Y. 311 pages. Bound in cloth. Price, $3 net. New York: McGraw Publishing Co.

First Principles of Chemical Theory. By Champion Herbert Mathewson. 130 pages. Bound in cloth. Price, $1. New York: John Wiley & Sons.

The Principles of Inorganic Chemistry. By Wilhelm Ostwald. Translated by Alexander Findlay 833 pages. Bound in cloth. Price, $5 net. New York: Macmillan Co.

The Theory of Valency. By J. Newton Friend. (Text books of physical chemistry; edited by Sir W. Ramsay.) 194 pages. Bound in cloth. Price, $1.60. New York: Longmans, Green & Co.

An Intermediate Course of Laboratory Work in Chemistry. By J. Wallis Dodgson and E. Kenneth Hanson. 130 pages. Bound in cloth. Price, $1.20 net. New York: Longmans, Green & Co.

A Shorthand Book of Oil Analysis. By A. Herman Gill. 179 pages. Bound in cloth. Price, $2 net. Philadelphia: Lippincott.

Examination of Water for Sanitary and Technical Purposes, by Chemical and Bacteriological Methods. By H. Leffman. 144 pages; illustrated. Bound in cloth. Price, $1.25. Philadelphia: P. Blakiston's Sons & Co.

The Dyeing and Cleaning of Textile Fabrics. A hand book for the amateur and the professional. By F. A. Owen, based partly on notes of H. C. Standage. 259 pages. Bound in cloth. Price, $2. New York: John Wiley & Sons.

Clays: Their Occurrences, Properties and Uses; With Special Reference to Those of the United States. By Heinrich Ries. 573 pages. Bound in cloth. Price, $5 net. New York: John Wiley & Sons.

Refrigeration: a Practical Treatise on the Scientific Principles, Mechanical Operation and Management of Refrigerating Plants Based on the Various Modern Systems of Artificial Cooling. By Francis Howard Boyer and C Dickerman. 109 pages. Bound in cloth. Price, $1. Chicago: American School of Correspondence.

Forging: a Manual of Practical Instruction in the Hammering, Working, Forming and Tempering of Wrought Iron, Machine Steel and Tool Steel, Including Details of the Modern Process of Electric Welding. By J. Lord Bacon. 112 pages. Bound in cloth. Price, $1. Chicago: American School of Correspondence.

Sheet-Metal Work: a Manual of Practical Self-Instruction in the Art of Pattern Drafting and Construction Work in Light- and Heavy-Gague Metal, Including Skylights and Roofing, Cornice Work, Etc. By W. Neubecker. 267 pages. Bound in cloth. Price, $3. Chicago: American School of Correspondence.

Compressed Air: Its Production, Uses and Applications: Comprising the Physical Properties of Air From a Vacuum to Its Highest Pressure, Its Thermodynamics, Compression, Transmission and Uses as a Motive Power. Very fully illustrated, including 44 air tables. By Gardner Dexter Hiscox. 694 pages. Bound in cloth. Price, $5. New York: Norman W. Henley Publishing Co.

Steam Boilers. Part 1: Construction of Boilers; Part 2: Types of Boilers. By Carl Stephen Dow and W. S. Newell. 141 pages. Bound in cloth. Price, $1 Chicago: American School of Correspondence.

The Boiler; Boiler Rules and Tables Used in the Construction, Testing and Operation of Steam Boilers, Rules Comprehensive and Exemplified. By Stephen Christie. 264 pages. Bound in cloth. Price reduced from $2.50 to $1.75. Chicago: Christie Publishing Co.

Vectors and Vector Diagrams, Applied to the Alternating-Current Circuit, With Examples of Their Use in the Theory of Transformers and of Single and Polyphase Motors, Etc.; With Diagrams. By C. F. Smith and Walter Cramp. 208 pages. Bound in cloth. Price, $2.50 net. New York: Longmans, Green & Co.

The Old Cannon Foundry Above Georgetown, D. C., and Its First Owner, Henry Foxall; Reprinted from the Records of the Columbia Historical Society. By Madison Davis. 55 pages. Paper binding. Lancaster, Pa.: New Era Printing Co.

BOOK REVIEWS.

Alloys and Their Industrial Applications. Edward F. Law, Associate Royal School of Mines, London. 8 vo., 268 pages, 57 cuts, 42 microphotographs. Price, $4. Philadelphia: J. B. Lippincott Company. London: Charles Griffin & Company, Ltd.

We are pleased to welcome another good book on alloys: that is, a book not of the cook-book recipe order, but an intelligent, scientific discussion of a field where the light is at present breaking fast. Furthermore, the treatise is altogether modern in its spirit; each chapter has at its close a bibliography; it is, moreover, full of bright observations and useful suggestions. One of the best innovations is the adoption of 100 and 1000 diameters as standard magnifications, so that, the enlargement being aways the same, the mind may easily and instinctively compare the size of grain, constituents, flaws, etc. We heartily second the recommendation that these powers be adhered to wherever they are suitable for the alloy in hand

We know of no book on alloys giving a more readable, exact and intelligent review of the subject; it is particularly recommended to students and technically trained persons wishing enlightenment in this difficult, yet fascinating, metallurgical field.

* * *

The Chemistry and Literature of Beryllium. By Charles Lathrop Parsons, professor of inorganic chemistry in New Hampshire College. 180 pages. Price, $2. Easton, Pa.: The Chemical Publishing Co.

This is an excellent monograph on beryllium, written by the well-known secretary of the American Chemical Society

"The book is written with the main object in view of saving preliminary study and labor to future investigators of beryllium and to point out some of the peculiarities of this interesting element which are apt to lead the novitiate toward erroneous conclusions. Especially it is desired to call attention to the fact that a large proportion of its accredited compounds are in reality but indefinite solid solutions. This condition of the literature beryllium is due to the abnormal salts, giving rise to solids of almost any degree of basicity or to solutions with decreased osmotic effects. Accordingly, results of analysis, freezing points, etc., give little evidence of the true nature of its compounds, unless accompanied by proved definiteness of composition, a proof too often omitted throughout the whole field of inorganic chemistry, but nowhere more than in studying beryllium and its compounds."

The first part (71 pages) contains chapters on metallic beryllium, normal compounds of beryllium, acid salts of beryllium, double salts of berryllium and basic salts of beryllium. The second part is a very valuable bibliography, with concise, yet rather full abstracts of all original papers and articles on beryllium, and references to abstracts of such papers. An authors' index and a subject index concludes the book.

* *

Organic Chemistry. Including portions of Physical Chemistry. For Medical, Pharmaceutical, and Biological Students. (With Practical Exercises.) By H. D. Haskins, A. B., M. D., and J. J. R. Macleod, M. B., D. P. H. First Edition. Price, $2 net. New York: John Wiley & Sons.

To write a short text book and impart to the student a sci-

...ries, in a brief simple, ... matter. Professors ... in their book on Organic Chemistry for ... pages show that they are fa... and that they fully appre... ...ge of this branch of science for ... and biological student.

... applied the existing theory to ... The application of physicochemical ... of action of the commonly used ... not only demonstrates the importance of a ... chemistry to the medical student, but ... book extremely interesting. It does not ... chemistry a compilation of a lot of dry facts, as ... consider it, but it increases its value in the stu... ...more interesting study, and gives him ... that the many physiochemical actions whic... ...in the human system.

... the authors explain the reactions of the organic com... ...which take place when organic com... ...through the human system. Also in several cases ... authors give the occurrence of certain comp unds present ... explaining thereby their chemical reactions in the ... system.

The authors fully realize that the most important of recent ... in medical science are those relating to the chemistry ... organic substances which enter into composition ... tissues and fluids, and to the physicochemical laws ... influence most physiological processes. Thus, ... the discovery of the constitution of the purin ... most of the urinary constituents, of sugars and fats ... has demonstrated the importance of organic and physica... chemistry to the medical, pharmaceutical and biological stu... A striking illustration of the importance of these branches ... chemistry is the recent application by Arrhenius of certain ... laws in explaining the mode of action of anti-... ...

Considerable attention is given in the first portion of the ... to a description of methods employed for purifying and ... the purity of substances. A full chapter gives the prin... ...of physical chemistry as applied to molecular weight de... ...and the theories of osmosis, solution, etc., while ... facts of physical chemistry are inserted where they can ... conveniently be studied along with organic compounds. ... describing the various groups of organic substances there is ... as the representative of each group, where possible, a ... of general or biological importance.

The practical exercises in the book embody the idea of accu... ...and tend to give the student a grasp and clear understand... ...of the subject of organic chemistry.

* * *

Synthetic Perfumes and Flavors. A lecture delivered at ... University. By Alois von Isakovics. 70 pages. ... N. Y.: Synthetic Scientific Laboratories.

This lecture was delivered by invitation last year at Columbia ... College of Pharmacy, Department of Chemistry. ... treats the subject as briefly as possible, selecting ... the examples of the formation of various bodies ... and extensive application. We to-day manufacture ... in the laboratory about 150 distinct perfumery ... products, all raw materials for the use of the ... industry, most of which materials must be com... ...of constituents in order to be available for ... application and to give the true natural flower ... effect.

The lecture is most fascinating reading. It conveys a pleas... ...while the author is not only master of his ... able to present it in a lucid and interesting ... Synthetic perfumes and flavors form a chapter ... which is in itself of peculiar interest.

Theory and Calculation of Transient Electric Phenomena and Oscillations. By Charles Proteus Steinmetz. 581 pages; 102 illustrations. Price, $5. New York: McGraw Publishing Co.

This book represents the results of a number of years of work by the distinguished author, and is undoubtedly his most important contribution to the science of electrical engineering.

The introduction treats the electric circuit, explaining in words the inter relations of the various factors of electric, magnetic and electrostatic energy, and defining the various phenomena and constants of electric, magnetic and electrostatic circuits, which are of universal importance.

Section I is devoted to transient phenomena in time, which heading includes the treatment of the phenomena occurring in both direct-current and alternating-current circuits when subjected to sudden instantaneous charges in current or e.m.f.

Section II is entitled "Periodic Transient Phenomena" and treats the phenomena in circuits which are periodically interrupted or reversed.

Section III treats of transient phenomena in space. Although the whole book is more or less pioneer work, this is especially true of the third and fourth sections. This section treats the distribution of waves in long transmission lines, the distribution of alternating flux in magnetic circuits, the distribution of alternating current in electric conductors, and the velocity of propagation of the electrical field. The data and discussion given here should be useful to those working with long-distance transmission lines for power, long-distance telephony, and wireless transmission.

Section IV combines sections I and III, treating transient phenomena in both time and space. This section is the masterpiece of Dr. Steinmetz. In it he has developed general equations for the energy factors of electric circuits, which take into account both time and space phase displacement. From the general equations are treated: Standing waves, traveling waves, free oscillations, phenomena occurring at transmission points in the line, and inductive discharges.

The treatment throughout is clear and concise, and the physics is well explained. Each subject is first discussed in words, then developed mathematically, the results discussed and the conclusions drawn. The engineer on the firing line will be chiefly interested in the statement of the problems and the results, while the entire development can be worked through by the student. All those interested in long-distance transmission lines, extensive underground distribution systems, long-distance telephony, regulation of machines, wireless transmission, lightning phenomena, surges, etc., will find here the first real treatment of the theory involved.

* * *

Social Engineering. By William H. Tolman, Ph.D. With an introduction by Andrew Carnegie. 384 pages, 43 illustrations. Price, $2. New York: McGraw Publishing Co.

In the brief introduction, Mr. Carnegie maintains that socialism talks speculatively, while individuals work practically, curing evils that socialists point out. "This is the right division between the individualist and the socialist." The thought is loosely expressed, but is worth thinking out to its logical conclusions.

Dr. Tolman "points out," and in so far is a typical socialist according to Mr. Carnegie's dictum, but we know that in practice he also performs and cures; he is, therefore, also a typical individualist. He discusses his topics in the following order: "Promotion of Efficiency of Employees," "The Social Secretary," "Hygiene," "Safety and Security," "Mutuality," "Thrift," "Profit Sharing," "Housing," "Education," "Recreation," "Social Betterment," and "Does It Pay?"

If there is an electrochemist or metallurgist who is not either an employer or an employee, such may possibly have no use for this book; all others are recommended to "read, mark, learn and inwardly digest" its highly useful contents.

Electrochemical and Metallurgical Industry

VOL. VII. NEW YORK, MAY, 1909 No. 5

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York
EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH.D.....*President*
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Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, MAY, 1909.

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Niagara Falls Meeting of the American Electrochemical Society.

For the third time the American Electrochemical Society is to hold a general meeting at Niagara Falls. The two former meetings, in 1902 and 1903, are unforgotten by those who had the good fortune to attend them. But from all indications it seems certain that this year's meeting will break all previous records, not only in attendance, but in the importance of the professional proceedings. The program, printed on another page, shows a long array of papers on important and interesting subjects. To the special feature of the program—the symposium of papers on the electrometallurgy of iron and steel—we have already called attention at this place in our last issue, though even this part of the program has been further strengthened by lately announced papers by Messrs. Bennie, Catani, Hibbard, and Richards. It is to be sincerely hoped that many practical iron and steel men may participate in the discussion. If practical steel men and electrometallurgists come into closer professional contact for the first time on this occasion, immense good will result for all concerned. That the social functions will be as enjoyable and cordial as ever, goes without saying. And then there are the ever-young charms of the old falls, though it is not out of place here to quote Lord Kelvin, who once said that "the great cataract could never be beautiful until it had ceased to be such an awful and unlovely example of waste." To reveal the deeper beauty of the Falls, by reducing this unlovely waste, has been the privilege of the electrochemical settlement of Niagara Falls. Two elements have created industrial Niagara Falls—the natural power of the Falls, and, equal if not superior, the power of the men who have made Niagara the principal electrochemical center of the world

A Dictionary of Chemical and Metallurgical Material.

Within the next two weeks our subscribers and friends will receive a copy of our "Dictionary of Chemical and Metallurgical Material." By compiling this dictionary the publishers of this journal hope to have done something really useful. The object is not to give a directory of manufacturers, but a dictionary of machinery, appliances and material used in the chemical and metallurgical industries, giving as far as possible concise technical data on the special features of the different types of machinery, etc., made by different manufacturers. As nothing of this kind has been done before by others, and as this is our own first attempt, this first edition of our dictionary cannot be but far from perfect. But we hope to have made a good and creditable beginning, and we hand the dictionary over to our friends in the fond hope that they may use it and may find it useful, and that where they find us lacking they may favor us with their criticisms, which shall be carefully considered in next year's edition. Then, and then only, can we hope to gradually produce a work that conforms to our intentions.

Metallum Martis et Dea Electra.

The [illegible] twentieth century arrived, was the conquest [illegible] possibility. Sir Humphrey Davy played with his [illegible] battery in the Royal Institute and isolated sodium and [illegible]. Faraday actually put the electric current commercially to work, refining copper which contained gold and silver. Hall was the first to use Niagara in harness, and forced [illegible] emperes of unwilling current into a small bathtub of a pot for the isolation of aluminium; Willson discovered electric [illegible] calcium carbide and founded an industry which is [illegible] through all the earth. Castner has given us cheaper [illegible] by electrolyzing the most common salt on earth; Birkeland and Eyde take the air we breathe, and which we do not [illegible] because we always get it for nothing, and out of what costs nothing they make the electric arc bring forth nitric acid, which as nitrates makes crops grow and will keep the human race from prospective starvation. Betts refines lead; Wohlwill refines gold; Moebius refines silver; Gibbs produces chlorates for our matches; Acheson, graphite for our electric apparatus, not to speak of pencils and lubricants; also carborundum to grind and cut with; etc., etc., etc. And thus the electric current decomposes, isolates, compresses, combines, transforms, transmits, refines, corrodes, melts, vaporizes—in other words, has become the chemists' and metallurgists' most powerful and successful agent for solving all the knotty problems of chemistry and metallurgy, for doing what was before impossible.

* * *

And above all this turmoil of a century of endeavor, grand, serene, unaffected, "Metallum Martis" kept his majestic way. What had sparks from a cat's back, current from a battery, "juice" from a dynamo, the incandescence of resistance furnaces, the fervent heat of the electric arc, to do with the colossal industry of iron and steel, the metals made by millions of tons on the grandest scale known to metallurgy? Some poor enthusiasts spent their all, and other people's all, finding out the apparent certainty of the impossibility of the "electrometallurgy of iron and steel." And now, A. D. 1909, *mirabile dictu* a national society, with international affiliations, devotes one day of its annual meeting to a "symposium on the electrometallurgy of iron and steel." *The goddess Electra has conquered Mars.*

The Exhaustion of America's Iron Ores.

The visitor to the pleasing city of Sault Ste. Marie, Mich., during the month of May, will be impressed with two things. The first is the bracing and invigorating atmosphere and the second is the endless procession of monster vessels with red-stained hatches that is apparently taking place in the actual streets. Then if the visitor be of an imaginative turn of mind, he will hardly fail to be impressed with this concrete evidence of the importance of the metal iron in this age of metals and will begin to ponder on the future possible exhaustion of this country, for the cargoes are so large and their presence so recurrent. The visitor is assured that many thousands of actual tons of iron ore pass before his eyes in so short an interval of time is a practical exemplification of the rate at which iron ore is being dug out of the earth. This phase of modern life is perplexing. How long will we skim the cream of this rich country? When will we be forced to take up the skim milk? The stupendous amount of our annual production of mineral wealth is pleasing to the present statistician. But are we using nature's heritage wisely? The discussion of this question has been widespread and general. The conservation of our natural resources and the utilization of them without any useless waste is the only proper course for any nation that wishes to have its national life endure.

* * *

Mr. C. Willard Hayes, chief geologist of the United States Geological Survey, has prepared an inventory of the iron ore of this country in his recent report to the "Conservation Commission." Although it is confessedly in the nature of an estimate, yet as the estimate of a trained observer in the employ of the Federal Government to whom private corporations are willing to give information, it is interesting and illuminating. Mr. Hayes classifies iron ore as available and non-available. The second class has the possibility of future commercial use. He also classifies ore according to its geological formation. In this way it is possible to inventory the reserves and probable future additions to reserves reasoning on the analogy of such additions in the past. The production and consumption of iron and steel has grown at a much more rapid rate than the population. This great increase is due to the diversification of industry and the increasing uses and needs for iron and steel in our modern complex civilized life. In railroad engineering, electrical engineering, and structural engineering, steel is a necessity. As the rate of increase increases many predictions have been made as to the date of exhaustion of commercially available ores.

* * *

Many people have speculated about the question, which, of course, is of vital importance to a country interested so largely in manufacturing and transportation. The production of iron ore has grown by saltations in the past four decades. From 1870 to 1879, inclusive, it was 44,000,000 long tons. The next decade saw it 91,030,000 long tons. Even the hard times from 1893 to 1896 did not hinder the increase greatly, for production totaled in that decade nearly 164,000,000 long tons. In the last 10 years production has reached the enormous sum amount of 392,000,000 long tons. The fact that the deposits of high-grade ore in the principal districts were pretty well known in 1901 and in large measure controlled by several large companies, was made the central conception by a master mind of finance. The circumstance that practically monopolistic control of the natural resources could be attained by the consolidation of several large companies led to the formation of one gigantic corporation that dominates the steel interests in this country. This act has been but the logical conclusion of a series of industrial evolutionary processes, the successive integrations of the small homogeneous entities into one large heterogeneous entity. And it showed that the principles of evolution enunciated by Herbert Spencer hold good in business economics as well as in biology. This consolidation has taken place also by the reason of the large units that are now used. The trainloads, the ore-carrying vessels, the blast furnaces, the steel plants all are measured in terms of hundreds of tons. And the capital to finance such operation is likewise measured in large units, millions of dollars. The simplicity attained through this is one reason for the success of what otherwise might be

failure because of unwieldiness. But more important in the consolidation was the unification of ownership of the ore properties.

* * *

The present outlook for the rapid exhaustion of the known ore fields is much different from that disclosed in the discussion of eight years ago. In the first place the extent of the high-grade ore lands has been increased by prospecting, especially to the extreme west of Mesabi. With the modern methods of prospecting by drilling and of mining by the "caving" system and the application of modern hoisting engines and the transmission of power by the electric current, it is possible to mine ore much deeper and to open up deposits whose character was unfavorable to working by the older appliances and methods. Improvements in the blast-furnace practice and in the refining of steel by the open-hearth process have widened in the past the chemical specifications for ore. This has the effect of increasing the amount of commercial ore by making non-available ore available. Recently the electric furnace has given promise of producing cheaply from semi-refined hot liquid steel, steel of highly excellent physical properties. Looking into the future a bit we see that the electric furnaces have increased the ore reserves—to use a figure of speech—because of the increased service and duty that a ton of steel refined electrically will give as against the service and duty of steel of the present grade. To epitomize, it can be said that the commercial gain may be expressed by the tensile strength of the new steel divided by the tensile strength of ordinary grades, multiplied by the present cost of production, plus the cost of electric refining. This is but a roughly accurate mathematical expression for the purposes of illustration.

* * *

The question of whether an iron ore is an iron ore or is not an iron ore—to resort to a taurian expression—is largely one of commercial availability. If an iron mine can be opened up, its ore transported to a locality where a blast furnace can be built and coal or coke transported to it, and the resulting pig iron be sold at a profit or turned into steel at a profit, its ore can be said to be commercially available. As Mr. Hayes puts it, "the interaction of various factors is the best criterion of availability." The principal iron ore district at present measured in terms of pig iron is the Lake Superior district. Of this the Mesabi range is the chief tonnage producer. Incidentally, it might be remarked that Mesabi as late as 1898 produced a relatively small amount of ore, and its ores were not then classed as commercially available. Their extremely soft nature made their treatment in the blast furnace extremely difficult. Accordingly, reasoning from this past history, it must be expected that in the future the same process of making ores once regarded as valueless will be recurrent. Mr Hayes from private sources places the ore of present grade to be mined in the Lake Superior iron regions at three and one-half billion tons. Practical iron men consider this rather high. Possibly two billion tons is a fairer figure.

* * *

The most significant remark in Mr. Hayes' entire paper is that the average percentage of metallic iron in the iron formation, excluding the beds now considered ore, exceeds 37 per cent. As many countries, for instance Germany, use ore running less than 32 per cent iron to some extent, it is safe to say that the use of these hard silicious ores is bound to increase. The comparison of this ore with the ore used abroad is not altogether a fair one, for in the low-grade foreign ores the lime and silica are present in partly fluxing proportions. But in fact considerable hard taconite ore or ore of this general class but running higher in iron (about 45 per cent) is used because of its physical nature and freedom from phosphorus, when mixed with softer ores high in iron but with phosphorus above the Bessemer limit. The amount of this rock above 37 per cent is practically unlimited and is given as 72,000,000,000 tons. The fact that so much scientific brains with practical and engineering ability is guided in the iron business now by minds of rare financial talent, would point to the utilization of these ores in the not so distant future at or near their place of occurrence, with the working up of their silica and alumina when mixed with lime as a by-product "blast-furnace cement." In that event the coal from the fields of the middle West would be transported to the head of lake navigation in vessels now returning empty and coked in by-product ovens. The ore would be smelted for metallic iron and cement and all products used in the then existent large local centers of consumption. This should take place some time before the middle of the present century.

* * *

Next to the lake district, the most important iron ore region, both from a standpoint of present and future development, centers at Birmingham, Ala., and includes the eastern part of Tennessee. Here large supplies of coal and limestone lie in close proximity to the iron ore. This combination makes the cost of producing pig iron at the Southern furnaces very slow, and the past 15 years has seen pig iron sold at times at extremely low figures. Its future as a steel center is not so promising by reason of the fact that steel making does not seem to be possible of being successfully conducted in the hot Southern climate. We should rather look to this district as a producer of pig iron to be used elsewhere in the foundry trade or at Northern steel plants. Third in importance is the district called in the catalog "the Northeastern." These ores in the Adirondack Mountains and Jersey hills are largely titaniferous magnetite. Usually they require magnetic concentration, and, furthermore, improved blast-furnace practice. The fact that they are close to the large centers of pig-iron consumption, such as eastern New York and the New England States, enhances their chance for immediate future exploitation. Lack of mining and transportation has restricted their development. But with the price set upon "ore in ground" enhanced by the large consolidations of the past decade these facilities are being vastly improved.

* * *

In the Western Mountain States, there are many large deposits of hæmatite of metamorphic or igneous origin, but the production of ore from them is confined to one locality in Wyoming and another in Mexico. Their future utilization will be deferred to some distant date. Their extent is more or less unknown and with lack of a large market for pig, of good coke, of railroad facilities, possibilities in this field do not seem promising. The future probable success of the electric ore-furnace will render some available, but at most they will add but a mite as their contribution to the pig-iron supply of this world in our generation. With the removal of the tariff on

iron from foreign sources are at once made commercially accessible to the blast furnaces at or near tidewater. Cuba now furnishes two large companies with iron ore and even with the proposed tariff on ore will supply them with more ore in the next five years. Canada, north of the Lakes, has been and is now being prospected for mineral, but its future as an ore producer will be largely in the direction of satisfying demands of home consumption. Iron sulfide deposits are being exploited the world over as sources of the raw material for both the sulfuric acid industry and the blast furnace. But the iron production from this source, though promising to be actually large, will, of course, be small compared to the total production. But here again improved metallurgical treatment with the recovery of by-products has widened the iron-ore supply.

* * *

Considering the question of the future of the iron business and its necessity for enormous tonnage of its raw material, it is quite plain that the latest metallurgical methods when combined with proper business judgment are continually opening up vast and unsuspected sources of iron ore. Each successive advancement in the price of pig iron stimulates this endeavor and tends to keep the price of pig iron from advancing materially. The great law of compensation and correction applies here. It is even doubtful if measured in the logical unit—the wage of the unskilled laborer—whether the price of pig iron has much increased over the days when little value was placed on Mesabi's leases. With the great supplies of capital that can be handled in large units, the production of economic values out of supposedly valueless raw materials is becoming surer and more satisfactory. Considering this tendency and the tendency to operate at the highest metallurgical and industrial efficiency, the utilization and exploitation of iron ores will increase greatly our national wealth. The vast size of this country of "unlimited possibilities" will undoubtedly develop areas now unknown or slightly known into producers of iron ore. Combining all these factors with the significant fact that iron is not destroyed by consumption, but that a high percentage of all iron returns to the market in the form of scrap, leads us to the conclusion that the so called future "iron famine" is not greatly to be dreaded. Indeed, the Cassandra-like prophecies of the pessimists who pointed out the year 1940 as the apogee of the United States pig-iron production and its decline subsequent to that date, are, to say the least, beside the mark. Any decided rise in price would in 10 years so stimulate prospecting for new sources of ore and metallurgical research for new processes, as to greatly increase the future production. In the "age of aluminium reinforced concrete," the millennium will be seen not so far distant

A New Era of Fine Steel.

A distinctly new era is being inaugurated in the steel trade—an era of the manufacture of fine steel. As is often the case when a sweeping change occurs in any branch of human affairs, there are many contributary causes which seem all to focus their influence upon one point of time, when really what is mistaken for the focal point is simply a center of diffusion. Some of the influences come to bear earlier and some later, the individual forces not being clearly recognized until the aggregate is seen. When we say there is being inaugurated an era of the manufacture of fine steel we do not mean that the quality of every ton of steel is necessarily to be greatly improved, nor do we mean to lose sight of the fact that some fine steel has always been made. We know that fine steel was the first steel produced and that the material which is now meant when the term steel is used without any modifying phrase is a later invention, a material which the Germans have been disposed to refuse to call steel at all. What we mean is that the proportion of fine steel to total steel produced is going to increase very rapidly until it constitutes a large percentage instead of an almost negligible percentage.

* * *

There are no statistics of American steel production in which the segregation is on the basis of quality, the segregation being only as to process of manufacture. From these statistics, however, one can obtain a rough approximation of the proportion of fine steel produced. The earliest year in steel statistics is 1867, the record for which is 2679 gross tons of Bessemer steel ingots and castings, no open-hearth steel, and 16,964 tons made by the crucible and other processes. Then we have the following decennial statistics, with the figures for the past three years added:

		Open-hearth.		Miscellaneous.		
	Bessemer.	Acid.	Basic.	Crucible.	Unclassified.	Total.
1870..	37,500	1,339		29,911		68,750
1880..	1,074,262	100,851		64,664	7,558	1,247,335
1890..	3,688,871	513,232		71,175	3,793	4,277,071
1900..	6,684,770	853,044	2,545,091	100,562	4,862	10,188,329
1906..	12,275,830	1,321,653	9,658,760	127,513	14,380	23,398,136
1907..	11,667,549	1,270,421	10,279,315	131,234	14,075	23,362,594
1908..	6,116,755	696,304	7,084,568	*	*	

*Not yet reported.

All the crucible steel and the greater part of the acid open-hearth steel may be regarded as fine steel. A large portion of the Bessemer product was hard steel, but is not to be considered fine steel in the sense in which that somewhat broad term is applied here.

* * *

In 1880, when 100,000 or 150,000 tons of fine steel was produced, the proportion it constituted of the total steel output, in the neighborhood of 10 per cent, is not significant, for at that time there was a large tonnage of wrought iron being produced (1,641,880 gross tons of rolled iron in 1880) which material was afterward replaced very largely by mild steel, an incident which is not of material import in this connection. It is a perfectly legitimate citation, however, that the total steel production increased by 115 per cent from 1900 to 1907, while the production of crucible steel increased only 30 per cent, and the production of acid open-hearth steel only 42 per cent. There has been a rapid increase in production of high-speed and other very fine steels, but the tonnage, as compared with that of mild steel, naturally remains negligible. It remains, then, that up to date the great mass of the so-called "steel" produced—more than 95 per cent of the total—has been simply mild steel or steel which is hardened by the presence of a moderate amount, less than 1 per cent, of carbon.

* * *

This alignment is destined to undergo a striking change, through the combination at this time of a number of influences. These influences are partly commercial and partly technical. The commercial influences make it particularly desirable that fine steel should be adopted for certain purposes, while the technical influences comprise the furnishing of means whereby

the steel can be produced advantageously. If it costs a certain price per ton to improve the quality of steel, then the desirability of doing so will increase as the cost of producing a ton of ordinary steel increases, the cost per ton of improving remaining stationary. Of the finer steel a smaller quantity is required to do a given work, and the higher the cost of the fundamental material the greater is the saving from this fact. In the middle nineties Lake Superior ore was "as cheap as dirt." Leases at 25 cents a ton on very good ore deposits went begging. In Alabama the outcrops of fairly good ore veins were being used, with a relatively low cost for mining. In a dozen years the fundamental conditions have changed, the cost of mining being greatly increased while a sufficient proportion of the original deposits has been mined to make the question of ultimate exhaustion one of academic interest at least, since with the 1907 rate of mining the known ore reserves in the Lake Superior region would be exhausted in less than half a century. Thus the value of ore has increased along with the cost of mining. At this point human nature has introduced an interesting factor. A comparatively high present value was set upon Lake Superior ore in the ground a few years ago. As present value is a function of interest charges, increasing heavily as the time of realization is deferred, the steel trade has favored the alignment of manufacture and use which would make for the earliest exhaustion. Its desire has been for "tonnage," leaving to the demand of the consumer rather than to its own initiative any movement toward finer steel whereby tonnage would be reduced while the same service would be furnished. There has also been a material enhancement in the value of coking coal in the ground and in the cost of producing coke from it. Thus the proposition of the cost of raw material to total cost of producing a ton of steel has greatly increased. Thereby the desirability of improving the quality of the steel has been likewise increased.

* * *

When steel wears out in the use to which it is put the increased price which can be paid for better steel is a matter of interest and sinking fund charges. If the life of the steel be indefinitely long the interest charge is everything, the cost of replacement being negligible, and the cheapest steel is adopted. If the life be indefinitely small, interest charge is negligible and the cost of replacement is everything. It pays to buy steel at double the price if it will last twice as long. Between these limits it is a matter of computation. At 6 per cent interest, the interest charge and the sinking fund charge against material which must be replaced every 11 or 12 years are equal. For each period of life a computation can be made as to how much more one can afford to pay for steel if thereby the life is increased by so much. Now if the conditions of service are so changed that a given piece of steel must do much more work each year of its life, the period of life is shortened, the sinking fund charge is increased and there is more room for saving by decreasing it through using steel which will last longer at the expense of a greater interest charge.

* * *

This change of conditions has been taking place steadily with the railroads. In 1890 the total ton-mileage of freight moved per mile of track was 380,000; in 1900 it had increased to 547,000, while in 1907 it increased again to 719,000. These figures understate the case in all probability, for the proportion of siding and yard track has probably increased, while the density of traffic on certain much-used stretches has probably increased more than has the average movement. On account of greater speeds and more concentrated load, the duty upon a given rail has been greatly increased, proportionate to freight movement. These influences shorten the life of a rail and greatly increase the sinking fund charge for replacement, permitting a saving by increasing the interest charge through using a more costly rail, but reducing by a greater amount the sinking fund charge. The extreme case is found in some yards or on some main-line curves where the life of an ordinary rail is measured by days rather than by months or years. At such points steel costing a very high price per ton can be employed.

* * *

With a given tensile strength there is a length of suspended cable which will break of its own weight. Just under that limit the cross-section required to support a load in addition is very large, and a high premium per ton of steel can be paid for load-carrying capacity. Those regions are being approached in an increasing number of cases as mining operations are being carried deeper and deeper. Several years ago skyscrapers reached a height which made the employment of better steel, particularly for the lower members, appeal very strongly to the engineering profession, on account of the great increase in the proportion of load to be carried which was furnished by the steel itself. The appeal in turn of the engineers to the steel mills did not meet with much response, however, since, as already suggested, the spirit actuating the manufacturing trade was the desire for tonnage.

* * *

The influences determining the selection of steel of one grade or another in the cases just referred to lie within the operation itself. In the case of automobiles, air ships and flying machines there are extraneous influences of the greatest importance, which present necessities of reducing weight quite superior to the question of first cost. These influences are not new; they have been growing steadily. From late in 1904 until October, 1907, the capacity of steel mills was strained and deliveries were so delayed that buyers as a rule were glad to get regular material. There was little opportunity for them to insist upon special steels, as there was ample demand from one quarter or another for all the ordinary steel which the mills could produce. Since the latter part of 1907 some steel capacity has been idle, and the commercial opportunity is presented for the buyer's changed requirements to be considered. Leisure is afforded for study of the conditions and the incentive has arisen for obtaining orders by applying suction when formerly the orders flowed under the pressure of their own head. The fine steel which is thus about to come into statistical prominence will be partly alloy steel made by former processes and partly fine steel made in electric refining furnaces. It is quite certain, however, that the alloy steel, too, will be made in electric furnaces. It will be largely a growth from beginnings already made. For years there has been some use of cast manganese steel in frog and crossing work; as the use of steel of similar durability extends to yard track and main line curves the tonnage will be rapidly augmented, and so through many lines of use where pioneer work has already been done.

Program of the Niagara Falls Meeting of the American Electrochemical Society.

The program of the fifteenth general meeting of the American Electrochemical Society, to be held at Niagara Falls, Canada, May 6, 7 and 8, is as follows:

All the sessions of the society will be held in the convention [illegible] Clifton Hotel, Niagara Falls, Canada.

The whole session of **Thursday**, May 6, will be devoted to a symposium on the electrometallurgy of iron and steel. The following papers will be presented during the morning:

Robert Turnbull, resident American engineer for Dr. P. L. T. Heroult: "The Heroult electric steel furnace."

Paul Girod, director, Société Anon. Electrometallurgique Procédés Girod, Ugine, Savoie, France: "The new Girod electric steel works."

Dr. A. Kjellin, electrometallurgical engineer, Metallurgiska Patent Aktiebolag, Stockholm, Sweden: "Developments of the induction and combination furnaces."

Cav. Ernesto Stassano, director, Forni Ellettrici Stassano, Turin, Italy: "Electrometallurgy of iron and steel."

Remo Catani, electrometallurgist of the Société Elba, Portoferraio, Elba, Italy: "Large electric steel furnaces in the iron and steel industry."

Charles A. Keller, general manager, Société des Etablissements Keller-Leleux, Livet, Isère, France: "A contribution to the study of electric furnaces for the electrothermic treatment of iron and steel."

Gustave Gin, electrometallurgist, Société Procédés Gin, Paris: "A contribution to the electrometallurgy of iron and steel."

Henry D. Hibbard, consulting engineer, Plainfield, N. J.: "The present value of electric steel."

F. A. J. FitzGerald, consulting electrometallurgist, FitzGerald & Bennie, Niagara Falls: "The application of the Lash process to the electric furnace."

P. McN. Bennie, consulting metallurgist, FitzGerald & Bennie, Niagara Falls: "Electric-furnace pig iron in California."

Joseph W. Richards, professor of metallurgy, Lehigh University: "The electric-furnace reduction of iron ore."

In the afternoon there will be a general discussion of the above papers, and if time is left, the following papers will also be presented:

C. A. Hansen: "Furnace electrode losses."

Carl Hering: "The working limit in electrical furnaces due to the 'pinch' phenomenon."

E. F. Northrup: "A new type of ammeter for the accurate measurement of alternating currents above 1000 amp."

Charles F. Foster: "A new radiation pyrometer."

E. F. Northrup: "The automatic registration of temperatures."

In the evening, at 8 o'clock, Dr. E. G. Acheson, as the retiring president of the society, will present his presidential address, the subject of which will be "The electrochemist and the conservation of our national resources."

On **Friday** the annual business meeting of the society will be held in the morning, which will be followed by the presentation of the following papers:

E. L. Kern: "Addition agents in electrolytic plating plants."

S. A. Tucker and E. G. Thomssen: "Electrolytic precipitation of lead and zinc as affected by the addition of certain organic compounds."

H. H. Patten and W. R. Mott: "Electrodeposition of some metals from acetone solutions."

S. A. Tucker and E. G. Thomssen: "The deposition of platinum from aqueous solutions, using rotating cathodes."

W. J. McCaughey: "The electrodeposition of platinum."

John A. Yunck: "Electrolytic production of white lead and oxides."

G. A. Hulett: "Thermodynamics of the Weston standard cell."

H. E. Patton and W. J. McCaughey: "The electrolytic reduction of nitric acid—II."

For **Saturday** morning the following papers are on the program:

A. H. Patterson: "The probable electrical nature of chemical energy."

L. H. Backeland: "Bakelite and its electrical and electrochemical applications."

J. W. Turrentine: "A graphite cathode fish."

S. A. Tucker, W. A. Alexander and H. K. Hudson: "Relative efficiency of the arc and resistance furnace for the manufacture of calcium carbide."

C. I. Zimmerman: "Some physical properties of silicon."

C. F. Burgess: "Magnetic tests of some iron alloys."

O. P. Watts and E. R. Suhm: "Further experiments with calcium alloys as reducing agents."

F. K. Cameron: "Electrochemical methods of soil analysis."

J. W. Turrentine: "A modified oxy-hydrogen gas coulometer."

L. S. Palmer and R. C. Palmer: "Rapid electrochemical analysis—a comparison of several methods."

W. H. Walker: "An answer to Professor Ganz's questions on the corrosion of iron."

* * *

The program of social functions, excursions, etc., is as follows:

On Thursday evening after Dr. Acheson's presidential address a smoker will be held at the Clifton Hotel.

On Friday afternoon visits will be paid to the different power companies on the Canadian side.

On the evening of Friday, a banquet will be held at the Clifton Hotel.

On Saturday afternoon, visits will be paid to two of the largest electrochemical plants at Niagara. First, to the works of the Development and Funding Company, where the Townsend process for electrolysis of sodium chloride is in operation. This invitation is extended with the following qualifications: "All persons who are associated with similar or allied industries in the manufacture of caustic alkali and bleach are requested to confer with the manager, Mr. A. H. Hooker, or Dr. L. H. Backeland, and will be admitted under the condition that they extend a reciprocal courtesy to the management of the Development and Funding Company."

The second plant to be visited is the works of the International Acheson Graphite Company. After that the power house of the Niagara Falls Power Company and the power house of the Niagara Falls Hydraulic Power and Manufacturing Company will be visited.

On the evening of Saturday the Niagara Club will tender the society and its guests an "Open House" at the clubhouse, corner of Buffalo Avenue and First Street, Niagara Falls, N. Y.

* * *

The following program has been arranged for the entertainment of ladies:

On Thursday afternoon, Mrs. Edward Goodrich Acheson will entertain the ladies of the convention at a garden party at her home on Lundy's Lane, from 4 to 6 o'clock. Conveyances will be provided.

On Friday morning at 11 o'clock the ladies' committee has arranged for an automobile drive to Fort Niagara on Lake Ontario. After a picnic luncheon the return journey will be made by Niagara-on-the-Lake.

* * *

Mr. J. L. Harper is chairman and Mr. L. E. Saunders is secretary of the general Niagara Falls committee; Mr. F. J. Tone is the chairman of the executive committee. Chairmen of the other committees are: Mr. E. C. Speiden, entertainment committee; Mr. O. E. Dunlap, press committee; Mr. P. P. Barton, excursion committee; Mr. G. E. Cox, reception committee, and Mrs. P. P. Barton, ladies' committee.

American Institute of Chemical Engineers.

The semi-annual meeting of the Institute will be held on June 24 and 25 in New York City. Dr. J. C. Olsen, Polytechnic Institute, Brooklyn, is the secretary.

Iron and Steel Institute.

The annual meeting of the Iron and Steel Institute (of Great Britain) will be held on May 13 and 14, in London.

The Bessemer gold medal, 1909, will be presented to M. A. Pourcel, of Paris.

The list of papers to be presented is as follows:

"The Production of Iron Sheet and Tubes in One Operation," by S. Cowper-Cowles.

"The Preservation of Iron and Steel," by Dr. A. S. Cushman.

"The Manufacture of Peat Fuel," by Dr. M. Ekenberg.

"The Chemical Physics Involved in the Decarburization of Iron-Carbon Alloys," by W. H. Hatfield.

"The Relation of the Solubility of Iron and Steel in Sulphuric Acid to Its Heat Treatment," by Prof. E. Heyn and O. Bauer.

"High-Tension Steels," by P. Longmuir.

"The Bristol Recording Pyrometer," by P. Longmuir and T. Swinden.

"A Heat-Treatment Study of Bessemer Steels," by Prof. A. McWilliam and E. J. Barnes.

"The Value of Physical Tests in the Selection and Testing of Protective Coatings for Iron and Steel," by J. Cruikshank Smith.

"Further Experiments on the Ageing of Mild Steel," by C. E. Stromeyer.

"A Comparison of the Methods of Determining the Hardness of Iron and Steel," by Prof. T. Turner.

"The Rusting of Iron, and Modern Methods for Its Prevention," by Prof. W. H. Walker.

A supplement to the report on the Determination of Carbon and Phosphorus in Steel, presented by the special committee appointed in 1901, will be submitted by Mr. A. A. Blair.

The autumn meeting is to be held in London on Sept. 28, 29 and 30.

Electric Iron Ore Reduction in Sweden.

In our March issue we reported that Dr. Haanel has returned to this country from his investigation of the electric iron-reduction furnace of the Elektrometall-Aktiebolaget Ludvika, at Domnarvfet, Sweden. While the full account of the tests will be contained in the official report to be made by Dr. Haanel to the Canadian Government, we find the following notes by Professor Neumann, who has seen the furnace, in *Stahl und Eisen* for Feb. 24:

It is a 1000-hp, three-phase furnace with carbon electrodes and with a shaft, similar in design to a blast furnace. The height of the shaft is 5.5 m (18 ft.). "Here is a possibility of utilizing the reducing nature of the carbon monoxide as in the blast furnace, the furnace gases are employed together with other gases." The consumption of coke per 1000 kg of pig iron produced has been reduced to 275 kg. Though the ore and coke contained sulphur (0.55 per cent), the sulphur content in the pig iron was very low, 0.005 per cent. The slag contained only 0.35 per cent iron.

The Iron and Steel Market.

There has been a general improvement in the tonnage of steel business placed. The buying trade is still proceeding with the utmost conservatism and placing orders only for early delivery. It is obvious that all material bought and delivered is passing promptly into ultimate consumption. Stocks are extremely low all along the line from the steel mill to the point of final consumption. The country is really "short" of steel products, as it is transacting its business with stocks far below the quantity normally involved in carrying on activities of the present volume. A movement to augment stocks would require a large increase in production, but the probability is that the present conservative policy will continue, and that production will do no more than increase gradually and that only after the summer dullness has come and gone.

The present rate of production is really quite satisfactory. Thus far this year pig iron has been produced at a rate exceeding 21,500,000 tons a year, against a rate of 14,000,000 tons in the first half of last year and 18,000,000 in the second half, while the greatest calendar year's output was 25,781,361 tons, in 1907. Until 1905 the best calendar year's production was only 18,009,252 tons, in 1903.

There has been some accumulation of pig iron stocks, but the stocks, above a fair normal, do not exceed about a fortnight's production and have required many months in the accumulation. They are held chiefly by merchant furnaces unwilling to sell at the present price level.

Open market prices on bars, plates and shapes have yielded about a dollar a ton since last report. The recession was due in large part to the inauguration of quite aggressive competition between the United States Steel Corporation and the Jones & Laughlin Steel Company, growing out of the former interest booking a plate order from the American Car & Foundry Company at an unexpectedly low price, the Jones & Laughlin Steel Company, with another independent steel producer, having hitherto supplied this consumer.

Shading in wire products became more pronounced about the middle of April, a concession of 10 cents a keg being made on nails in the case of particularly desirable business, while a concession of 5 cents a hundred on wire nails, plain wire and barb wire is quite general. No formal reduction in wire products has been made on this movement, the present nominal market being that established by the $2 a ton reduction of June 9, 1908. As there was an advance September 3, 1907, of $1 a ton, the present nominal market is only $1 a ton below the regular market ruling the first eight months of 1907. It is recognized that when a general reduction in wire products is made it will necessarily be a heavy one, and it has been the desire to postpone the readjustment until the spring business is well over. A general reduction may now be made at any time, and is likely to be $4 to $6 a ton from the present nominal basis, $1.95 for nails and $1.80 for plain wire.

Pig Iron.

There has been a material change in the complexion of the pig iron market, suggesting the probability that after three months of stagnation and steadily declining values a general, although possibly slight, upturn will occur. In Southern iron there is no question that the turning point has been passed. Through the first three months of the year Southern pig iron declined from $13 to $11, Birmingham, with a few forced sales in March at $10.50 for spot cash. Late in March large inquiry appeared, and in the first three weeks of April sales were made totaling at least 200,000 tons, for prompt and third quarter delivery, with some tonnage running to the end of the year. This business was all on the basis of $11, Birmingham, and furnaces then began advancing prices for forward delivery. For early delivery a little iron can probably be picked up at $11, but for third quarter $11.50 is demanded, while some producers are asking $12, and even $12.50 for fourth quarter.

Following this movement there appeared considerably heavier inquiry for Northern iron, including, for foundry iron, the Westinghouse Electric & Manufacturing Company, 10,000 tons; the General Electric Company, 11,000 tons, and the Massillon Iron & Steel Company, 24,000 tons. Most of this iron has been bought. Inquiries for basic iron exceeding 50,000 tons appeared from large steel-casting companies and small steel

works which roll their product. Bessemer iron has been entirely neglected. Prices of pig iron in the Central West declined in the early part of April, and at the close of the month may be quoted for early delivery, May and June, at $14 for basic and No. 2 foundry and $14.75 for Bessemer, f.o.b. valley furnace, while for third quarter delivery from 25 cents to 50 cents more is asked

Billets and Sheet Bars.

There has been scarcely any market movement, as consumers are well covered by long-term contracts. Shipments of both billets and sheet bars have increased on such contracts. Pittsburg prices remain at $23 for billets and $25.50 for sheet bars, although it is possible these figures might be shaded slightly on very desirable business. A sale of 500 tons of forging billets is reported at $26, delivered Chicago, comparable with $24, delivered, for rolling billets.

Finished Material.

Standard rails have continued in light demand, partly because the railroads do not feel in position to make extensive improvements and partly because there is a more or less general expectation that the standard price of $28 will be reduced by $3 or $4, if not for this season then for 1910. There has been increased competition in light rails and $22, Pittsburg or Buffalo, can be done on sections 20 lb. to 45 lb.

Plates have been quiet except for a good movement to pipe mills and steel-car works. The regular market, for fairly desirable orders, is 1.25 cents, Pittsburg, against the price of 1.30 cents developed in February. On especially attractive business this would be shaded.

Structural material continues to lead in point of activity. On large lots involving definite structural jobs inside prices are made, probably down to 1.10 cents or lower. The openly quoted market is about 1.25 cents, against 1.30 cents, the price developed in February.

There has been a good run of business in steel bars, while specifications against old contracts have been quite satisfactory. The openly quoted market has declined from 1.20 cents to 1.15 cents, at Pittsburg, and from 1.35 cents to 1.30 cents, at Chicago. Attractive tonnages have been taken down to 1.10 cents, Pittsburg, in which case it is understood the full freight of 18 cents to Chicago is added.

Sheets and tin plates have remained at prices first developed when the general readjustment was undertaken, ordinary carloads of sheets being 2.25 cents for black and 3.25 cents for galvanized, 28 gage, while on attractive orders 5 cents per 100 lb. less is usually done. Tin plates are $3.40 per 100-lb. cokes in carload or larger lots. The tin mills are running practically full, this being the busiest season of the year, while about 60 per cent of the sheet capacity is engaged.

CORRESPONDENCE

Cost of Water-power in Norway.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—I have read with interest several notes and articles in your journal on the cost of water-power. As I have been interested in the utilization of water-power in Norway for the last 18 years I send you the following information about the cost in Norway, which may be of interest to the readers of your journal. There is no doubt that the new Norwegian law on water-power, which is to be worked out, will make it more easy for foreign capital to be invested in enterprise in Norway.

The fjords are safe, very deep, and there are hardly ever any troubles from ice on the western and northern coast. In order to illustrate the cost of water-power, which, of course, differs according to the circumstances, I give you an estimate on the development of a 50,000-hp water-power on the western coast of Norway.

More than 6 cm (1585 gal.) of water per second are available for the whole year, with a difference of level of 880 m (2886 ft.).

The fall is divided into two steps, each of 440 m, one station being situated at the coast, the other station at a distance of 2500 m from the coast.

The estimate* for the development of 50,000 (metric) hp is as follows:

Cost of regulation ..... crowns	256,000
Tunnel—length, 3,000 meters.....	360,000
Steel pipes, 830 meters length for each fall, each crowns 675,000.....	1,350,000
Foundation for pipes	24,900
Freight and laying of pipes.....	50,000
Two turbine-houses	60,000
Turbines and generators (estimated at 6 crowns per h.-p.).....	300,000
Price of water falls, ground, etc.....	900,000
Total crowns	3,300,900 or $885,000

or about crowns 66 per metric horse-power (about $18 per horse-power) at the switchboard, including dynamos, and large ground of some 170,000 sq. m (about 1,830,000 sq. ft.), directly at a harbor free from ice and navigable for the largest ships.

Bergin, Norway. Henry E. Mohn.

Electric Steel for Rails.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—With reference to your recent articles commenting upon "the adoption of the Héroult furnace by the United States Steel Corporation," we feel sure that you are always ready to give credit where credit is due and therefore draw you attention to the fact that the Steel Corporation is not "the pioneer of electric refining of steel for large tonnage products." The corporation is only following the lead of the Rochlingsche Eisen- und Stahlwerke, who have made many thousands of tons of rails and other products in the Roechling-Rodenhauser furnaces, and to whose work in this direction the development and production of a high-class electric steel rail is due.

It is true that the largest furnace at present working is one of eight tons capacity, which gives an output of 100 tons per day, but designs are completed for 16-ton furnaces and manufacture of the same will be put in hand very shortly.

New York City. A. H. Strong.
American Electric Furnace Company.

-ite and -undum.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—When a new substance is to be named, I submit that the name to be invented should, in the interest of economy of time, space, and mental effort be short and distinctive, that is, different from others and easy to write, read, and comprehend.

The prevailing habit of giving to new substances names of from two to four syllables and ending in "undum" or "ite" or other "cribbed" ending, is surely wrong, and your readers include offenders addicted thereto.

A suitable name of four letters and of one or at most two syllables can usually be made up either arbitrarily or by using one or two letters from each of the chief words which might describe or suggest the new thing.

The ending "ite" should be reserved for minerals alone, where its necessary repetition causes waste, but where it is firmly intrenched by long acceptance and usage. To the layman all words ending in "undum" look alike.

Herbert Spencer noted that our language was made much easier to read because of the dissimilarity of the letters, they being of different shapes and heights, some extending above and some below the line, than if they were more uniform. The words as a consequence also have individuality. He also spoke of the force and convenience of short words.

Much irreparable damage has already been done in this line, but it is to be hoped that the amount will be made small in the future.

Plainfield, N. J. Henry D. Hibbard.

* Some figures of actual cost of power development in Norway are given on page 213 of this issue.—Ed.

The Works of the International Acheson Graphite Company at Niagara Falls.

Edward Goodrich Acheson shares with Charles M. Hall the honor of having founded the first electrochemical industries at Niagara Falls.

There is no necessity to describe in this journal Dr. Acheson's early pioneer work with carborundum and artificial graphite. A full illustrated description, by Dr. J. W. Richards, of the works and the process of the International Acheson

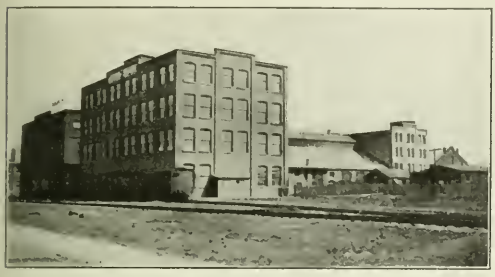


FIG. 1.—INTERNATIONAL ACHESON GRAPHITE WORKS.

Graphite Company in the summer of 1902 may be found in our Vol. I, p. 52 (October, 1902).

However, since 1902, the ever-active inventive genius of Dr. Acheson has brought about important developments in extending the applications of artificial graphite into fields of usefulness, undreamt of a few years ago.

It is perhaps not realized that the whole artificial graphite industry is only ten years old. The company was organized in 1899, with Mr. Acheson as president, which position he has occupied ever since. Other present officers of the company are: Mr. William Acheson Smith, vice-president, and Mr. O. E. Dunlap, secretary. The following sketch relates chiefly to the technical and industrial advances made by the company during the last seven years.

The development of the industry is indicated by the figures of power consumption. The company commenced the manufacture of graphite with 1000 hp. But this was soon found insufficient. In July, 1904, the plant was increased to 3000 hp, and now they are installing apparatus for using a total of 4000 hp. The fact that the almost universal business depression of the last year has not been felt at all by the company, is evidence of the soundness of this rapid development.

To indicate the manifold applications of artificial graphite, we mention only the following; it is used for electric work, as a powder for dry-battery filling, paint pigment, electrotyping, moulding and polishing, for the manufacture of lead pencils, for general lubrication, for rifle lubrication, and it is also mixed with grease and oil for lubricating purposes. Because of its remarkable purity, Acheson graphite, "Grade 1340," of which more will be said below, has come to be known as a perfect solid lubricant, and with the possibilities of "deflocculated graphite," the future of artificial graphite in the field of lubrication appears destined to be amazing.

Without repeating what we have formerly published on the process, we shall describe in this article the present equipment of the works of the International Acheson Graphite Company.

The superiority of artificial graphite over natural graphite is essentially due to the greater purity obtained by carefully selecting the raw materials.* These raw materials are assembled in a three-story structure having dimensions of 100 by 50 ft. This building is almost wholly occupied by large steel bins, crushing machinery, mixers, together with scales to weigh each ingredient that enters "the mix" for charging the furnace.

The charge is transferred from the raw materials building to the furnace room in large steel hoppers, picked up and handled by electric cranes, which also dump or place the material in the furnaces. The furnace room has dimensions approximately 100 by 230 ft. and contains 22 furnaces† capable of consuming 4000 electrical hp continuously.

After the electric-furnace operation is completed, the mass is permitted to cool, and the work of unloading the furnaces begins. The graphite is loaded into steel hoppers, and these are picked up by electric cranes, and carried to the grinding and storage building, which is four stories high, 45 by 100 ft. in dimensions, at the south end of the furnace room, where the product is discharged into a conveyor by which the graphite is carried up into large steel bins provided for storage purposes.

From these bins the "lump graphite" is led by spouts to tube mills, where it is ground into powder form. As the powder leaves the tube mill it goes through the air separator, where the coarse particles are removed and only that which is of the desired standard of fineness is permitted to pass to the mechanical packer, where it is placed in barrels or bags, as desired, for shipment.

This description relates particularly to the battery filler, paint pigment, and similar grades, but in the case of Acheson graphite, grade "1340," there is a marked difference in its handling and treatment.‡ The claim is made that this graphite is the purest and best in the world, and in order to have the product support this claim every effort within human power is directed to maintain the highest standard ever set for a graph-

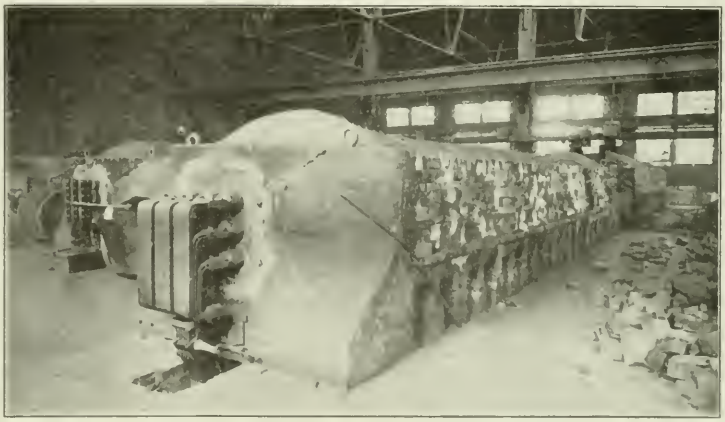


FIG. 2.—ACHESON GRAPHITE FURNACE IN OPERATION.

*See the article by Morris M. Green on the sources of raw materials for Niagara's electrochemical industries, our Vol. III, page 296.

†Concerning the design of the Acheson graphite furnace, see the article by F. A. FitzGerald, in our Vol. III, page 416.

‡Concerning the special method of making soft, unctuous graphite, see our Vol. IV, page 502.

99, which is a purity content of at least 99 per cent. While Acheson graphite, grade "1340," is guaranteed to be at least 99 per cent pure, none of this product is ever approved by the chemists in charge unless it ranges higher in purity content, its purity usually ranging close to 99.80.

The maintenance of this standard naturally requires extraordinary care and watchfulness. The raw material used, its loading into the furnaces, the operation of the furnaces, the cooling, all are features that demand and receive extra care, but even this watchfulness is increased when the time comes to unload a "1340" furnace

Four men are selected to do the work. Each man is a picked employee They bring into the furnace room large galvanized iron cans, known by them to be perfectly clean. The lids are down tight. The cans are placed right on the furnace, the walls of which have by this time been torn away. Two of the men have shovels. One handles a knife with a long and wide blade, while the sole duty of the fourth man is to raise and lower the lid of the can being filled.

The cans are numbered 1, 2, and 3, and into them is placed the graphite from a special section of the formation, the same number always indicating to the chemist and superintendent

FIG. 3.—SCENE IN PRODUCTS BUILDING.

the same special section of the furnace. The man with the knife indicates how far the furnace is to be uncovered, the distance not being great at any one time.

The shovelers do their work rapidly and carefully, the man at the can responding to their movements, shutting the lid down tightly the moment the shovel is withdrawn in order that dust or other impurities floating about the furnace may have no opportunity to get inside the cans. A surgeon performing an operation would not be more careful than are these men in the dissection of a "1340" furnace.

When filled, the cans of "1340" are removed from the furnace room to a special grinding room, better known as the lubricating department, where the graphite is disintegrated to a coarse powder. It is then passed through a concentrator to remove any hard graphite, after which it is placed in cans containing from 100 to 200 lb and samples taken from each lot or package

All of the samples are taken to the laboratory, which is located in a frame structure known as the Works Office Building with the offices of the superintendent, the chief chemist, the chemical and physical laboratories, and an electroplating department.

When the laboratory receives the samples of "1340," an ash determination is made by an assistant and the resulting ash turned over to the chief chemist for his examination, which consists in inspecting the ash carefully by microscope in order to ascertain if it has any gritty impurities. Should any be found the lot from which the sample is taken is at once condemned.

If the ash content of the sample be less than 1 per cent and no grit presents itself the lot from which the sample was taken is passed and is later ground in an impact pulverizer to an impalpable powder, the condition in which it is marketed.

However, as the "1340" comes from the mill the contents of each barrel is sampled very carefully. This new sample is sent to the laboratory and each barrel is held in bond until the laboratory approves the contents as being up to the high standard for this grade. This second analysis is made as a check on the first analysis as well as a safeguard.

When each barrel is approved by the laboratory as being up to the adopted standard it is released from bond and placed in stock.

In the manufacture of electrodes, etc., the various sizes are placed in the electric furnaces and graphitized, after which they are removed from the furnace to the shipping department in the products building, where they are boxed and shipped to all parts of the world. Concerning the process of graphitizing articles of carbon, like carbon electrodes, we refer to the descriptions of Richards and FitzGerald above quoted. As to the ease of machining graphite electrodes, see the article by C. L. Collens, 2d, in our Vol. I, p. 26.

The products building is 112 x 55 ft. in dimensions, four stories high. It is equipped with a large freight elevator, has electric light and is heated by steam. Large doors open on the north side to cars that stand on the tracks of the Niagara Junction Railway.

The bulk graphite, other than the "1340," is ground and stored in the new grinding and storage building previously mentioned.

In addition to the facilities recorded the company maintains and operates its own machine and blacksmith shops so that the works in their entirety are quite complete.

The plant improvements of 1908-09 have necessitated an expenditure quite considerable, which has given greatly increased output facilities. But there is still ample room for further extensions.

The most interesting and the latest development of artificial graphite is the invention by Dr. Acheson of a method for bringing graphite into the colloidal state. (For details see our Vol. V, p. 452.) This is done by treatment with a solution of gallotannic acid. In this condition the graphite remains permanently suspended in water or oil and is called by the inventor "deflocculated graphite." The suspension of deflocculated graphite in water has received the name Aquadag, its suspension in oil is called Oildag (the word dag being formed from the initials of "deflocculated Acheson graphite").

Aquadag was first developed and it was found by extended tests with aquadag as a lubricant that deflocculated graphite in water prevents the corrosion of iron and steel. Yet as Dr. Acheson wished to conquer the whole field, now covered by oil lubrication, he developed "oildag." It has already given most remarkable results in connection with automobiles; it reduces not only the oil consumption 50 per cent, but it increases considerably the available power and prevents pitting in the valves.

Oildag is constantly being subjected to new tests and it appears that the artificial graphite industry, after its splendid start with hard graphite in lump form and in form of graphitized carbon articles, has now entered, with soft unctuous graphite and aquadag and oildag, a career of unlimited possibilities.

It may be added that aquadag and oildag are products of the Acheson Oildag Company, which company controls the deflocculated graphite products.

Many well-deserved honors have been conferred on Mr. Acheson to show to him the appreciation of the scientific world. For the past year he has been the president of the American Electrochemical Society and at Lincoln's Birthday the University of Pittsburgh conferred on him the honorary degree of Doctor of Science, a tribute well deserved.

Alkali Chloride Electrolysis in Europe.

(From Our Berlin Correspondent.)

An interesting lecture on alkali chloride electrolysis was held on March 13 in the Hofmann House, in Berlin, by Prof. B. LEPSIUS, director of the Griesheim-Elektron Company.

In 1892, at the electrical exhibition in Frankfort-on-Main, the Griesheim company first exhibited electrolytic caustic soda. Numerous experiments and tests had been necessary to reduce Hoepfner's diaphragm process to commercial practice. The chief difficulties which had to be overcome were found in the manufacture of suitable cement diaphragms and carbon anodes. The carbon anodes, which weigh 15 kg (33 lb.), are made by pressing a mixture of lampblack and tar into suitable forms and baking them in porcelain furnaces; they last for about a year.

Professor Lepsius discussed the following three processes: the diaphragm process, the mercury-cathode process and the gravity process (glockenverfahren).

In diaphragm cells the cathodes are generally made of iron. In the Griesheim works the small sheet-iron boxes, in which the anode cells are suspended, are themselves the cathodes.

In the diaphragm process operation must be stopped when the proportion of caustic alkali in the catholyte has risen to 8 per cent, otherwise the amp-hour efficiency will be unduly reduced and oxygen will be set free at the anode, forming carbon dioxide which mixes with the chlorine gas.

This last disadvantage has been overcome in recent years by the use of ferric oxide electrodes,* made by melting iron oxide in an electric arc furnace. Much care was necessary to produce large electrodes and to prevent their cracking. With this improvement the evolution of oxygen at the anodes at 70° to 80° now results in the formation of potassium chlorate which crystallizes out and is removed from the cell from time to time. When the catholyte has reached a content of 8 per cent free alkali it is run off and fresh sodium chloride solution is filled in.

The caustic soda contains iron chloride, etc., as impurities. It is purified by osmosis on the counter-current principle; "the impure solution is passed through long gutters and brought in contact with water. The caustic diffuses quickly and is extracted, while the impurities remain back."

The Griesheim Company has built a second factory in Bitterfeld, near the large potassium salt deposits of the province of Saxony, where coal is also mined; the cost of power is here only one-half the cost in Griesheim, where Westphalian bituminous coal is used. A plant of the Allgemeine Elektricitäts Gesellschaft, also located at Bitterfeld, and works of the Griesheim-Elektron Company at La Motte, near Compienne, France, and near Barcelona, Spain, also use the same process. The Badische Anilin und Soda Fabrik also has a plant with this process in Westeregeln; the chlorine is here used in the manufacture of artificial indigo.

The Griesheim diaphragm process is now employed in works using 33,000 hp and producing per year 70,000 tons of caustic.

Professor Lepsius then discussed the Castner-Kellner **mercury-cathode process.**

If the anode compartment (in which chlorine is set free and sodium alloys with the mercury which here forms the cathode) and the cathode compartment (in which the sodium amalgam gives off its sodium, forming caustic soda and hydrogen) are electrically connected in series, a difficulty is experienced on account of the fact that a small portion of the sodium in the anode compartment does react with the chlorine. For this reason there is a deficiency of sodium in the cathode compartment. If the same current is used in the anode and in the cathode compartments there is not enough sodium in the amalgam to be changed into caustic soda in the cathode compartment. Hence part of the mercury will be oxidized. This must, of course, be prevented.

Two remedies are possible. The first is to shunt the cathode compartment by a proper resistance so that the current in the cathode compartment is less (by 14 per cent, according to Professor Lepsius) than in the anode compartment. The second is to short-circuit directly the amalgam with the iron cathode in the cathode compartment.

In the Salvay mercury process the amalgam runs off in a continuous stream and is chemically decomposed in a separate vessel.

The advantages of the mercury process are that there are no diaphragms; that the catholyte is very pure and may contain up to 20 per cent caustic soda; that the amp-hour efficiency is high, and that the anodes have a very long life. Disadvantages are the higher voltage (4.3 volts against 3.5 with the Griesheim process, according to Lepsius), the greater complication of the apparatus, and the large quantity of mercury required. For a 3000-hp plant 72,000 kg of mercury are required.

The gravity process (glockenverfahren) has been worked out by the Oesterreichische Verein für Chemische und Metallurgische Produktion in Aussig. This process is said by Professor Lepsius to have the following disadvantages: The current density is low so that an extended system of apparatus and a large area are required, and the voltage is high, 4 volts. In Aussig 25,000 bells are said to be in operation at about 3000 hp.

If the caustic may be considered to be the chief product of alkali chloride electrolysis, the chlorine is an important by-product. Chlorine is also made on a commercial scale by passing hot magnesium over chlorine, whereby magnesia is formed and chlorine is set free; at present about 10,000 to 13,000 tons of chlorine are still made from magnesium chloride.

In the Deacon process, which was formerly of great importance, hydrochloric acid gas is conducted over hot copper salts; at present the only German works making chlorine by this process is the Rhenania Company in Aix-la-Chapelle.

Most of the chlorine is now made by alkali chloride electrolysis. It is partly liquefied and shipped in bottles or tank-cars of several thousand kilograms content. But the greatest part of chlorine is used for bleaching-powder manufacture.

More recently crystallized calcium hypochlorite is obtained at Griesheim by more carefully evaporating the chloride of lime solution; since it contains much more active chlorine it is more valuable than bleaching powder.

Other products made from electrolytic chlorine are carbon tetrachloride, tin tetrachloride, chloral, chloroform, etc.; it is also used in large quantities in the artificial-indigo industry.

There is very much less demand for the hydrogen gas set free at the cathode. The chief consumer in Germany is at present the air-ship industry. There will be an air-ship exhibition this summer in Frankfort-on-Main and the Griesheim Company will furnish every day 1000 cu. mm (35,000 cu. ft.) of hydrogen—free of charge. Another application of hydrogen is for welding and cutting with the oxy-hydrogen flame.

While Professor Lepsius had intended to speak on the application of electrolysis in chemical industries, in general, lack of time forced him to restrict his remarks to alkali-chloride electrolysis. There was an interesting exhibition of various products of electrochemical industries.

*See patent of H. Specketer, our Vol. III. p. 392.

The Works of the Carborundum Company at Niagara Falls.

Carborundum may properly be called the pioneer electric furnace product. It shares with calcium carbide the distinction of marking the beginning of the electrometallurgical art founded on the chemistry of high temperatures.

The Carborundum Company was organized in 1893 by Pittsburgh capitalists to work on a large scale at Niagara Falls the process of Mr E. C Acheson, for making silicon carbide or

carborundum. The early development of the process and the achievements of the Carborundum Co. up to 1902 were described in full, with numerous illustrations, in an article by Dr. Jos. W. Richards, in our Vol. I, p. 50 (October, 1900). There exists also an excellent monograph on carborundum by Mr. F. A. J. FitzGerald, published as Volume XIII of the German serial of monographs on applied electrochemistry (Halle a. S., 1904).

However, since that time, the carborundum industry has made rapid advances. Under the progressive management of its president, Mr. F. W. Haskell, the Carborundum Company has been able to create a rapidly widening field of usefulness

FIG. 1.—FURNACE BUILDING OF CARBORUNDUM COMPANY.

and a steadily increasing demand for carborundum so that this electric-furnace product, absolutely unknown twenty years ago, is now indispensable in the most varied industries.

Technical advances have kept pace with commercial progress; they are the result of a series of able and important inventions of Mr. F. J. Tone, the works manager of the company. The former apparatus has been improved, the process has been modified in various respects, and new processes have been worked out for the manufacture of other electrometallurgical products besides carborundum.

The following sketch of these very interesting developments will, therefore, be welcome to our readers. We have avoided to repeat well-known facts or well-known pictures, as they are easily accessible in the publications referred to above. The

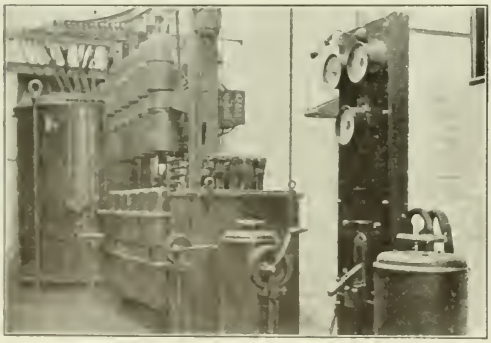


FIG. 2.—1600-KW TRANSFORMER.

object of the following article is to sketch only the new developments of the last years.

Carborundum.

The first commercial carborundum furnace as operated in 1893 was a loosely constructed box of fire brick, consuming 75 electrical hp and producing in each run about 50 lb. of carborundum. The furnace employed to-day utilizes 2000 hp and has an output of 15,000 lb. of crystalline product in each run. The annual production in 1892 was 2145 lb. In 1907 it was 7,532,670 lb.

The present electrical equipment of the Carborundum Company for the manufacture of carborundum has a capacity of 7000 hp. This consists of 1000 and 2000 hp units, each electrical unit being connected to a series of furnaces of the same capacity. The transformers are of the water-cooled type with a rating of 1600 kw and receive the primary current at a voltage of 2200 and a frequency of 25 cycles. The secondary voltage is capable of a wide range of regulation. This is accomplished by the cutting out of primary coils by means of oil switches which are actuated by solenoids. These solenoids are all controlled from a master controller which operates them in regular order by the revolution of the controlling drum. The transformers are located close to their respective lines of furnaces, but are controlled by one attendant from a central room in which the meters and controllers are located.

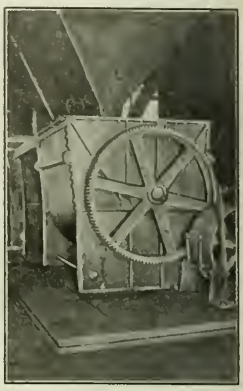


FIG. 3.—MIXING CARBORUNDUM CHARGE.

The present type of furnaces is constructed of sectional walls of fire brick set in iron frames.* These sections are assembled and taken down by means of an overhead crane, and in this way the labor incident to intermittent furnace operation has been greatly reduced. The mixture is charged into the furnace by an overhead conveyor. One main line of conveyor leads

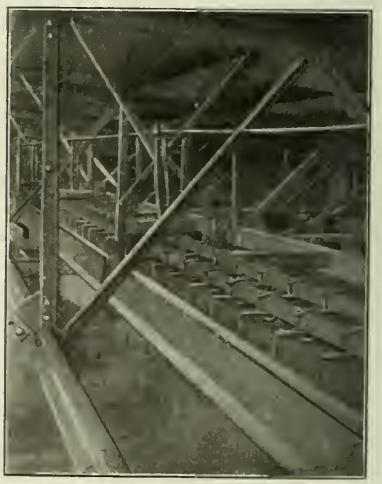


FIG. 4.—LINE OF FURNACE CONVEYORS.

from the mixing-room over the several furnace units, and from the main conveyor extend branches over each furnace unit so arranged that any furnace may be loaded therefrom. A furnace unit consists of five furnaces, only one of which is

* F. J. Tone, Patent No. 800,515. See our Vol. IV, p. 502. Concerning the fundamental principles of the design of the carborundum furnace see the article by F. A. J. FitzGerald, in our Vol. IV, p. 53.

operated at a time, the others being in the process of cooling, discharging or loading, as the case may be.

The first use of carborundum was as a substitute for diamond powder and for the manufacture of dental wheels. From this limited field its uses have extended into many arts, mechanical, chemical and metallurgical, but its application as an abrasive

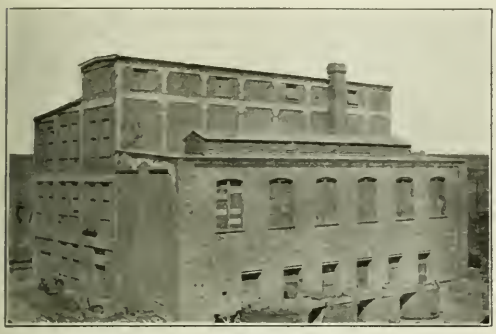


FIG. 5.—GRADING BUILDING.

is still of chief importance and consumes the major portion of the production. The infinite variety of grinding operations into which carborundum enters is worthy of note. It is used not only for the grinding of all classes of metal, but for all conceivable forms of wood, leather, paper, pearl, stone and almost every substance which requires to be shaped or polished.

A large portion of the world's marble production is now cut and shaped by carborundum wheels. The slab of marble which in former practice was molded by laborious hand methods is now passed through machines and cut to molds of the most intricate profile at the rate of 10 ft. per minute.

Paper pulp is now refined by carborundum. Huge carborundum blocks are placed in the beaters and the abrasion of the

FIG. 6.—SIFTING CARBORUNDUM.

moving pulp upon these blocks draws out and opens up the fiber.

Non-slipping stair treads in public stairways and building entrances subjected to heavy travel are widely used, the method in this country being to insert in iron or steel plates strips of carborundum grains set in a matrix of cement. In France carborundum grains are now used as a top dressing in cement blocks and walks and a careful observation of three steps in the Gare-de-Lyon, a Paris railway station, shows no perceptible wear in fourteen months after the passage of fourteen million travelers.

Carborundum has in recent years developed many uses outside of the abrasive field which strikingly illustrate its diversified properties. Molded into the form of rods it is used as resistance units by the electrical manufacturers in the construction of lightning arresters. A carborundum wireless detector has been developed which is used in a large number of the wireless telegraph stations of the De Forrest Company.

The refractory applications of carborundum are also of

FIG. 7.—TAPPING A SILICON FURNACE.

importance. Outside of the crystalline zone of the furnace is a zone of green amorphous-like material which contains carbon, silica, and oxygen, in the form of various compounds representing the partial reduction of silica by carbon and having the chemical formula Si_xC_xO. It is much used in brass and oil-burning furnaces. Zinc muffles made with an interior lining of carborundum are largely used on the Continent.

Carborundum has been found by recent experimenters to have an index of refraction higher than that of the diamond.

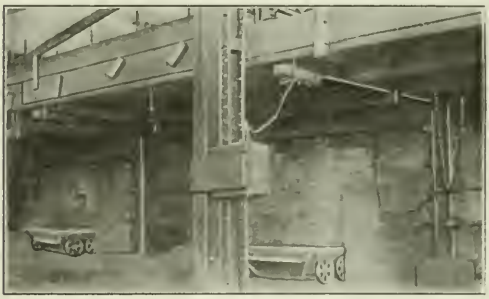


FIG. 8.—TAPPING FLOOR OF SILICON FURNACES.

This fact makes its optical properties a matter of great interest, and the use of carborundum as a gem would be quite possible if it could be produced in a transparent form and in crystals of considerable size. The brilliancy or fire of a precious stone

is in direct proportion to its refractive power, and transparent carborundum excels all known substances in its ability to break up light.

Among the new products of carborundum may be mentioned a dense or compacted form which may be produced by several processes. One process for the manufacture of this form is described in a recent patent of F. J. Tone, No. 913,324 (see our April issue, p. 107). This form of carborundum has very great toughness, but is not as hard as the regular form. A similar material has been recently described in our January issue, p. 24, under the name of "silundum." Its electrical conductivity is greater than that of the common form of carborundum and as a resistance element in electrical heaters, cooking apparatus, and other forms of resistors it has important applications.

The Carborundum Company are now making many abrasive products besides carborundum. During the past year they have entered into the manufacture of garnet paper and cloth, emery paper and cloth and corundum wheels. A new artificial abrasive is also being produced by an electric-furnace process from aluminum silicate.* This product has been given the name of *"aloxite"* and consists principally of fused alumina.

The process of manufacture consists in smelting a mixture of a pure aluminum silicate, such as kaolin, carbon and iron oxide, the carbon being so proportioned as to reduce the silica but to leave the alumina unreduced. The reduced silicon unites with the iron to form ferrosilicon, while the alumina is fused and freed of practically all of its impurities. A furnace is used with two depending vertical electrodes, the furnace structure being built of fire brick, the receptacle being open on top to permit the feeding in of the charge.

FIG. 9.—AN 800-LB. PIG OF SILICON.

After a large ingot of the material has been formed, the operation is stopped and the furnace cooled. The aloxite is broken up and crushed and thereafter treated in the same manner as other abrasive materials. The ferrosilicon for the most part settles to the bottom of the furnace, from which it may be tapped.

* F. J. Tone, U. S. Patents 906,172, 906,173, 906,338 and 906,339 (see our January issue, p. 32).

Silicon.

The Carborundum Company has been the first to produce pure silicon commercially, the process for its manufacture having been developed by its works manager, F. J. Tone, U. S. Patents 745,122, 833,427, 842,273 and 869,276 (see our Vol. II, p. 111; IV, 464; V, 141). The production is now carried on by the company on a large scale.

FIG. 10.—SILICON CRYSTALS FROM CAVITY OF PIG OF SILICON.

The furnaces used are large arc furnaces having two depending vertical electrodes extending a considerable depth into the charge, which consists of coke and sand. The furnace structure is of fire brick, lined on the interior with carbon. Each furnace has a capacity of 1200 hp and the metal is tapped out at intervals of a few hours in pigs of from 600 to 800 lb.

Silicon is made in grades containing 90, 95 and 97 per cent silicon. The following are typical analyses of some of these grades:

Silicon	90.60	95.71
Iron	6.70	2.24
Manganese	.08	...
Aluminium	2.35	1.96
Phosphorus	.02	.01
Carbon	.22	.08
Sulphur	.00	.00

The principal use of the 90 per cent silicon metal is in the refining of steel where it replaces the higher grades of ferrosilicon. It accomplishes the deoxidation of the metal in the most efficient manner. About five hundred tons of 90 per cent silicon metal have been sold for this purpose during the past year.

Another important use of silicon is as a reducing agent in the manufacture of low-carbon ferro-alloys, such as ferrovanadium, ferrochromium and similar alloys. Silicon has a greater deoxidizing capacity per unit of weight than aluminium and is, therefore, very efficient for this purpose.

An alloy of calcium and silicon which is now being introduced into the steel trade for the refining of steel is produced by the reduction of calcium oxide by silicon. This has called for a small tonnage of the material and will doubtless increase.

With constantly decreasing cost, silicon is destined to become a metal of common use. When the problem of its manufacture was first undertaken it sold at $4 per pound. It is now marketed in carload lots at about $120 per gross ton.

Its use will be greatly extended when certain problems are solved in connection with its industrial applications. One of the most important of these problems is the production of silicon castings.

Such castings would be of great utility as acid containers and for the manufacture of various kinds of apparatus which

are subjected to the action of acid and are widely used in the chemical industries.

There will undoubtedly be a large market for such silicon or silicide containers when the technical difficulties of casting silicon have once been overcome.

Silicon is now produced in the form of small castings, such as rods for electric resistances, but it is difficult to cast perfect forms unless the section is thin. Castings of considerable thickness are porous and subject to shrinkage strains. Resistance rods ¼ in. in diameter are easily cast in lengths of 12 in., and several of these rods may be electrically welded together to form longer resistances.

Aluminium Welding.

By M. U. Schoop.

In my article in the April issue of this journal I have given an outline of my method of autogenous welding of aluminium. In the present article I will deal chiefly with the field of application of this process and with the types of burners specially suitable for the process.

First, however, I wish to refer again to the method of Heraeus, who was the first to weld aluminium. His method is based on the fact that at a certain temperature (around 550 deg. C.) aluminium softens and that in this plastic condition it can be united or welded with a similarly heated piece with the aid of hammering. The fundamental principle is, therefore, the same as that of the very old iron-welding method with which every blacksmith is familiar.

The characteristic feature of the method of Heracus is the maintenance of an exact temperature. At too low a temperature no union is obtained, while at too high a temperature the aluminium gets brittle or softens and spatters away under the hammer.

To employ the correct "critical temperature" is purely a matter of experience and skill, and for this reason the use of the method involves difficulties, especially if sheets of less than 2.5 mm (one-tenth of an inch) are to be welded, and if aluminium alloys, like magnesium, partinium, etc., are to be welded.

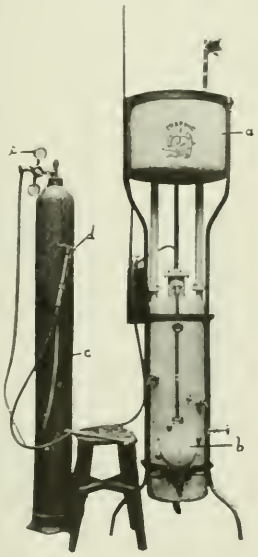


FIG. 1.—OXY-ACETYLENE WELDING OUTFIT

Articles welded according to this method were first exhibited at the World's Fair in Paris, in 1900. As a matter of curiosity it may be mentioned that there exists a U. S. patent for a process which is identical with that of Heraeus. It is No. 710,958 of March 21, 1901, granted to M. Wisniewska, and claiming "the process of welding aluminium which consists in bringing the thoroughly cleansed parts of aluminium to be united into contact, and applying heat to the same until the metal begins to soften, whereby they may be welded or permanently united."

A patent for welding aluminium, which is not without a certain interest, is the German patent, No. 109,433 of 1899, which refers to a "process of welding aluminium and aluminium alloys with or without flux or reducing joints." At the moment of welding it is intended to tear or remove mechanically the oxide film formed during heating. It is recommended to use an electric current whereby one pole is connected to the articles to be welded and the other pole to a suitable carbon electrode. It is said that by this method the aluminium oxide is electrolytically decomposed and the welding process accelerated. The pressure applied is 6 to 8 volts.

FIG. 2.—WELDED ALUMINIUM CONTAINER.

I have tried to weld aluminium according to this patent, but have been unsuccessful, although I have been familiar for many years with methods of welding iron and lead (Electrochemical and Metallurgical Industry, 1905, p. 260, on Autogenous Lead Soldering). Though the melting coil of lead in degrees Centigrade is just one-half that of aluminium (330 deg. for lead and 650 deg. for the aluminium, and the thermal conductivity of lead is less than that of aluminium, yet the current may rise to 50 or 60 amperes, when welding lead sheets of 2 mm (80 mils) in thickness. If aluminium sheets can really be welded by this method, the current consumption will probably be so high that the process will hardly be commercially practical.

In several patents (for instance, the Belgium patent of Mazzucchelli, 206,355, of 1908) it is proposed to remove the oxide film formed on heating by mechanical means, by scraping with suitable instruments. If thick, solid articles are to be welded it is possible to break through the superficial oxide film with an instrument, and to cause in this way a union of the parts of aluminium. But with thin sheets this method cannot be used.

There are some other patents for welding aluminium of a more or less hypothetical character. But of methods for soldering aluminium there exist an enormous number, which indicates the activity in this field and the demand for a simple and reliable method for soldering or welding aluminium.

Without discussing in detail these patents, I will say that by far most of the joints made by soldering aluminium will lose after a short time their original strength; and this is always the case if the solder contains tin.

A quick method of determining the quality of an aluminium joint is to place the article into hot acidulated water, whereby the evolution of little hydrogen bubbles can be directly observed with the eye. This is due to local electrolytic action whereby the joint will be decomposed. This electrolytic action will progress rapidly, if in the galvanic metal series the foreign metal in the solder is removed from aluminium.

The future will show whether it will ever be possible to find an aluminium solder, satisfactory in every respect, and which would correspond to the universally used solder (lead and tin) for soldering copper, iron, etc., and the application of which would simply require the use of the blow-pipe. On the basis of more than 1000 experiments which I have made, I doubt the possibility of finding such a simple solution.

Applications of Aluminium Welding.

Chemical and electrical engineers are interested in the first place in the manufacture of large aluminium vessels, for evaporating and distilling. They are even preferred to nickel

and copper vessels on account of their lower price and lighter weight. In breweries, the containers made of wood or of enameled iron plates are being replaced advantageously by welded aluminium containers. Continuous contact with the aluminium metal does not result in the so-called "yeast poisoning," which occurs with most other metals. In general, in hygienic and sanitary respects, aluminium is the ideal metal. For this reason, cooking and kitchen utensils of aluminium have found very much favor with the general public within a comparatively short time

FIG. 3.—WELDED ALUMINIUM CONTAINER.

Aluminium has a high resistivity against most acids. According to Prometheus, the German army workshops have been using for the last three years aluminium vessels for working with acids, and the results have been very satisfactory. Nitric acid or sulphuric acid and their hot vapors attack aluminium only slightly, and after two years of use the vessels could still be satisfactorily used. From former experience with brass, copper, and bronze vessels, these had to be replaced in the same time by new vessels. The use of aluminium vessels in working with acids results, therefore, in considerable saving. An additional advantage of aluminium vessels is that they are of lighter weight and can be easily handled.

The Aktien Gesellschaft für Aluminiumschweissung in Zurich has carried out a long series of tests in order to determine the attack of aluminium by acids, especially by nitric acid. The results may be briefly summed up by stating that the attack of aluminium by nitric acid is greatest for an acid concentration of 30 per cent, and this attack will go on the more rapidly the greater the impurity of aluminium, other things being equal. With lead the situation is similar.

Of the different kinds of aluminium made in Europe, the English metal was found to be the best, and was least attacked by acids. As an example, I may mention comparative tests made with 100-per-cent acetic acid which showed a loss of weight per 100 sq. cm surface of 1.66 mg for English sheet aluminium, and 5.77 mg for Swiss sheet aluminium.

A typical analysis of English sheet aluminium is 0.312 per cent silicon, 0.256 per cent iron, 0.006 per cent tin, hence total impurities 0.644 per cent, so that aluminium is 99.34 per cent pure.

It is certain that not only the chemical composition, but also the structure and the condition of the surface of the sheet aluminium are of importance with respect to the attack by acids. The following experiments will show this.

Take three hard-rolled sheets of aluminium of equal size, of which I is carefully polished, II has a frosted surface, while III is heated over a Bunsen burner, until a chip of wood begins to char. These three sheets of aluminium will behave very differently in an acid bath

Number I is attacked least, and number III most. Number III is very similar to cast aluminium and has a lower specific weight and a more crystalline structure than the rolled and hard material of I and II.

Extended fields of application of aluminium containers are aeronautics and the automobile industry, the yacht industry, the manufacture of vacuum apparatus, montejus and other apparatus for chemical industries, of iron containers with an aluminium lining, etc. Aluminium is also especially useful for apparatus of the fat, glycerine, and stearine industries, for transportation vessels of all kinds, for cooling and heating pipes, for extraction apparatus, etc.

Burners for Welding.

Concerning the most suitable type of burner and the most suitable gaseous fuel, there may be a difference of opinion. For thick aluminium sheets it is advisable to use the oxy-acetylene burner which permits the production of intensive local heat effect within a short time. Fig. 1 represents the apparatus of Michel-Molas, of Paris. The water is filled into *a*, the carbide into *b*, *c* is a steel container for compressed oxygen (125 atmospheres), *d* the burner and *e* the manometer.

For welding thin sheets, the oxy-hydrogen blowpipe is sufficient, or the oxygen-illuminating gas blowpipe. The last one is especially useful in places where illuminating gas is available, as nothing more is required but a compressed-oxygen container with a reducing valve, several feet of rubber pipe, and the blowpipe.

For welding iron sheets the composition of the illuminating gas (its contents of sulphur, phosphorus) has some influence on the result. On the other hand, at least according to my experience, the quality of the gas is of no importance for aluminium welding. But it is important that the two gases leave the burner as an intimate homogenous mixture. This requirement almost contradicts the other practical requirement that, for the sake of safety, the two gases should mix only just before they leave the burner.

Backlighting may be avoided if the speed with which the gas mixture flows out of the burner is greater than the speed of propagation of the explosion.

For smaller welding work, so-called "saving burners" (Sparbrenner) have proven quite satisfactory, in which the flame is automatically reduced in size as soon as the workingman puts the burner aside; the oxygen supply being cut off entirely, and the hydrogen supply being reduced to such an extent that only a small flame remains burning. (See Swiss patent 41,627, Chalumeau a gaz, 1908.)

Those readers who want to learn more concerning the burner problem, may be referred to the recent excellent German book of Th. Kautny, "Handbuch der autogenen Schweissung," published by Marhold, in Halle a. S.

There is no special difficulty in the practical application of autogenous aluminium welding. Especially men acquainted with lead burning, skilled in handling the burner and careful

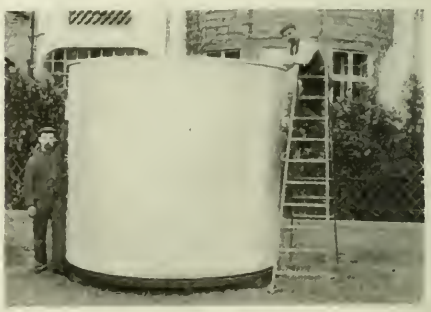


FIG. 4.—WELDED ALUMINIUM CONTAINER.

in observing the operation, will learn to weld aluminium within a few days.

With some skill it is also possible to avoid the tensions within the material which easily may develop in the case of thick sheets or in repairs of thick pieces, like automobile motor cases.

Garenne-Colombes, near Paris, France.

Conductivity and the Valuation of Electric Conductors.

By E. F. Northrup, Ph.D.

When solid, round copper conductors of easily determined conductivity were almost exclusively used for transmitting electric power, it was not difficult or confusing to estimate their relative values as conveyors of energy. But now, we find competing with solid copper conductors, stranded, aluminium and bimetallic conductors. This variety of competing conductors, when taken in connection with the two methods in vogue of defining conductivity, has led to a certain confusion of ideas as to the precise meaning of conductivity and the best way of determining and stating the relative worth to the user in dollars of conductors of different qualities and types.

Assuming the above to be true, a clear statement of the accepted definitions of conductivity and the necessary relations which follow from these definitions will not be without value in assisting to a better understanding of how to estimate the relative worth of different electric conductors. We shall attempt this, and add a brief account how conductivity may be measured most conveniently and accurately.

The electrical engineer considers that the sole function of an electric conductor is to convey electric power from the generator of the power to the translator of the power. Thus viewed, that conductor will be the best one to use which will transmit a given power, a given distance with a specified loss, and cost the least money. The loss of power is proportional to the ohmic resistance of the conductor, and it is essential to be able to determine the relation between the resistance of a given length of any conductor, and the price at which such conductor, of given length and resistance, may be purchased. This relation is seldom given directly in price lists. The catalogs of leading wire manufacturers quote prices for their product as so many cents per pound for conductors of certain sizes, or so many dollars per 1000 ft. for conductors of specified diameters. They generally add a statement of the guaranteed per cent conductivity of the material, often neglecting, however, to state the standard of conductivity upon which their guarantee is based.

We shall first give under one general view the accepted definitions and the necessary relations that follow, so anyone can easily compute the relative power-conveying value of any conductor from the data as given in catalogs and price lists, however they are presented, provided this data is sufficient.

General and Specific Properties.

Electrical conductance is a general property of an electric circuit, and is the reciprocal of electrical resistance, or

$$C = \frac{1}{R} \qquad (1)$$

where C is conductance and R is ohmic resistance.

The dimensions of C are $L^{-1}T$ in electromagnetic measure and LT^{-1} in electrostatic measure, the one being the reciprocal of the other. Commercially, conductance is considered only in electromagnetic measure.

Since resistance is equal to the e.m.f. E divided by the current I, conductance is defined by the relation

$$C = \frac{I}{E} \qquad (2)$$

If E is made equal to a unit potential difference between the terminals of any conductor, then conductance becomes a measure of the current which flows between the same terminals. As thus defined, *conductance* is a general property of *electric circuits* and in no way defines the current-carrying quality of the material forming the circuit.

We may treat, however, of the property of the *conductor* whereby its quality is considered as a conveyor of electric current, but the term which should be used then is *conductivity*. As specific gravity is the relation of the density of a substance, in its actual state, to the density of water under specified conditions, so conductivity is the relation of the conductance of one conductor in its actual state to that of another conductor of like length and cross-section or like length and weight under specified conditions of temperature and resistance.

The conductor with which other conductors are compared, for finding their conductivities, is taken as a conductor having standard conductivity and called the standard conductor. When this standard conductor is specified in a particular way in respect to temperature, resistance, length and cross-section, or length and weight, it is defined to have unit conductivity. Instead of the term conductivity, the term "per cent conductivity" may be used, this latter being equal to the former multiplied by 100. Though the term "per cent conductivity" is the more generally used, we shall make our calculations using the term conductivity to avoid the repeated use of the multiplying factor 100.

The dimensions of conductivity when expressed by the meter-millimeter standard are $L^{-2}T$ in electromagnetic measure and T^{-1} in electrostatic measure. Hence, in either the electromagnetic or the electrostatic system of units conductance = conductivity (by the meter-millimeter standard) × length. When conductivity is expressed by the meter-gram standard its dimensions in electromagnetic measure are LTM^{-1}, and, as will more fully appear later, conductivity by the meter-gram standard is proportional to conductivity by the meter-millimeter standard divided by a density.

Standards of Conductivity.

In every determination of the conductivity of any sample conductor, a comparison is made of its conductivity with that of an adopted standard. It is absolutely essential to be clear as to the standard of conductivity which has been adopted and the manner in which it is defined. The standard universally used in this country was recommended by the Standard Wiring Table Committee, Jan. 17, 1893. It is known as Matthiessen's standard. This standard is defined, however, in two distinct ways, and it would seem more proper to use the plural. Expressed in the forms most convenient for calculation, Matthiessen's standards as defined by this committee are as follows:

In respect to diameter, Matthiessen's standard of electrical conductivity is 1 m of round soft-copper wire of uniform cross-section, 1 mm in diameter, and having a resistance at 0° C. of 0.0203 international ohm. This definition applies equally to a wire of uniform cross-section, which may not be round, when the cross-section is $\frac{\pi}{4}$ sq. mm.

In respect to weight, Matthiessen's standard of conductivity is 1 m of soft-copper wire, which weighs 1 gram and has a resistance at 0° C. of 0.14173 international ohm. This definition presupposes a uniform cross-section of the wire.

Either or both of these two standards of Matthiessen are frequently used indiscriminately in making measurements of the conductivity of copper conductors, upon the confused assumption that they are equivalents, or only two ways of expressing the same thing. For these two standards to be equivalents a certain density for soft copper must be arbitrarily assumed. If the copper conductors of which the conductivity is sought happen to have this particular density, then and then only will the same result be obtained whichever standard is used in making the measurement. To show this, call A the meter-millimeter and B the meter-gram standard.

Let δ = the density of the copper of standard B.
" L = the length of standard B.
" s = the cross-section of standard B.
" W = the weight of standard B.
" l = the length of standard A.
" S = the cross-section of standard A.
" D = the diameter of standard A.

Let r_0 be the resistance at 0° C. of standard A and r_0' the resistance at 0° C. of standard B. We have

$$\frac{r_o'}{r_o} = \frac{LS}{ls}, \quad \text{also } S = \frac{\pi D^2}{4} \text{ and } W' = sL\delta$$

from which relations

$$\delta = \frac{4\, r_o' W'}{r_o \pi L^2 D^2} \qquad (3)$$

In Matthiessen's standards

$L = 100$ cm.	$l = 100$ cm	$r'_o = 0.14173$
$D = 0.1$ cm	$W' = 1$ gram	$r_o = 0.0203$

These values placed in (3) give

$\delta = 8.8895+$ which equals 8.89 within 0.0056 per cent.

It may be noted that the meter-gram standard when in the form of a round wire of density 8.89 is 0.3785 mm in diameter.

Now, assume a round wire 1 m long and 1 mm in diameter and of a measured resistance at 0° C. equal to r. In this case its conductivity is found by comparing directly its conductivity with that of standard A. If C_s is the conductivity sought, we have

$$C_s = \frac{1\ r}{1\ 0.0203} = \frac{0.0203}{r}$$

If the weight of the wire instead of the diameter is given, this weight being 1 gram, and its density not known, its conductivity can only be found by comparing it directly with that of standard B. Calling C_w the conductivity sought, if the wire has a resistance r as before, we have

$$C_w = \frac{1/r}{1\ 0.14173} = \frac{0.14173}{r}$$

Now this wire might be of light material or of copper in the form of a tube so as to have an outside diameter of 1 mm, as in the former case. If such were true, and the density not considered, one might be led to use, in finding the conductivity, either standard A or standard B. But since $\frac{C_w}{C_s} = \frac{0.14173}{0.0203} = 6.9817$, the result would be nearly seven times as large in the latter as in the former case. As will appear more fully later, if the diameter or cross-section and length only of a conductor are given, the meter-millimeter standard must be used in stating its conductivity, while, if the weight and length only are given, the meter-gram standard must be used.

To find the conductivity of a conductor in terms of one standard, when the conductivity of this conductor is given in terms of the other standard, necessitates a knowledge of the density of the material. If this density is 8.89, which is the basis upon which the meter-gram standard is connected with the meter-millimeter standard, then and then only will the conductivity of the conductor be the same to whichever of the two standards it is referred.

Thus if a wire manufacturer is turning out a uniform product of copper wire of density 8.878, which is stated to have a conductivity of 1 as referred to the meter-gram standard, this same wire would have a conductivity of 0.9987 if referred to the meter-millimeter standard. Yet, in the present understanding of this subject, purchasers would be little likely to press the question as to the exact basis upon which rests the manufacturer's statement of the conductivity of his product.

The value in dollars of a copper conductor, as will more fully appear later, is directly proportional to its conductivity. Hence, if in a sale of $10,000 worth of cable this is paid for on the assumption that its conductivity is 1 per cent greater than it really is, the purchaser will become defrauded out of $100.

As conductivity can be measured commercially to an accuracy better than 1/5 per cent, a clear understanding regarding the principles involved, and the standards referred to, should avoid all such unfair transactions. The money losses involved in a single transaction, resulting from a confused understanding of this subject, may amount to several hundreds of dollars.

In referring to the exact wording describing Matthiessen's standards it will be noted that "soft copper" is the material chosen for the standards. From this it might appear that it is essential to compare the conductivities of copper and all other conductors with standards made of "soft copper." This is by no means the case. In reality, the standards are fully and sufficiently defined in the following terms:

The standard of conductivity is any material in the form of a rod of uniform cross-section, 1 m long, which weighs 1 gram and which has an ohmic resistance at 0° C. of 0.14173 international ohm. To this definition should be added the following explanatory clause:

As comparisons of the conductivities of conductors with the above standard are usually made at temperatures other than 0° C., the material of the concrete standard is best chosen when it has a temperature coefficient which is the same as that of the sample conductors which are to be compared with it. If this is done the relative and not the actual temperatures of the standard and samples need be known at the time of the comparison. The coefficients being alike, if the temperatures of the two conductors under comparison are maintained alike, the comparison may be made with precision without regard to the temperature value. That the concrete standard of conductivity should be copper is only a matter of convenience when copper samples are being measured.

When iron or aluminium samples are to be measured iron or aluminium standards are the more convenient. If a copper standard is used for getting the conductivity of some other material, and the measurement is made at 0° C., or at some other temperature, and the effect of the different coefficients allowed for, by the nature of the definition, a correct result for the conductivity would be obtained, but not conveniently.

The standard of conductivity may be defined also as follows:

The standard of conductivity is a round wire of any material, 1 m long, 1 mm in diameter, which has a resistance at 0° C. of 0.0203 international ohm.

The two above definitions are equivalent when the material selected in both cases has a density of 8.89. The material having the above resistance and density may be found in copper, but not necessarily in "soft copper."

The same remarks as above apply to the desirability of choosing a material for the concrete standard to use which has a temperature coefficient the same as that of the samples which are to be compared with it.

It is thus seen that the introduction into the definitions of Matthiessen's standards of the term "soft copper" should be considered useful as being merely descriptive of a material quite frequently suitable to use for embodying the standards in concrete form. With the introduction of iron, aluminium and bimetallic conductors, copper is often a very unsuitable material with which to make concrete standards of conductivity.

Relations Which Exist Between the General and Specific Properties of Conductors.

The relations between the conductivity and the general properties of conductors, which are useful to know for ascertaining their capacity for conveying electric power and their money value, may be found as follows:

It is first required to find an expression for the conductivity of any round, homogeneous conductor of uniform diameter when referred to the meter-millimeter standard.

The ohmic resistance of any conductor at temperature T and temperature coefficient Θ' is, $r_T = r_o\Theta'$, r_o being its resistance at 0° C. If the conductor has a length L and is of uniform diameter D and of circular cross-section,

$$r_T = \frac{4\, kL\Theta'}{\pi D^2}$$

k being an arbitrary constant.

If $T = 0$, $\Theta' = 1$; and if $L = 1$, $D = 1$, then

$$\frac{1}{r_o} = \frac{\pi}{4\, k} = C_o,$$

which expresses the conductance of a round wire of unit length

and unit diameter at temperature 0° C. Then $k = \frac{\pi}{4 C_0}$

which value placed in the expression for r_T gives

$$C_0 = \frac{L\Theta'}{r_T D_z}$$

Similarly, for any other round conductor, of length l, diameter d, resistance R_t, at temperature t, and of temperature coefficient Θ, the conductance of unit length and unit diameter at 0° C. is:

$$C = \frac{l\Theta}{R_t d^2}$$

Conductivity being the ratio of the conductance of one conductor, called the sample, to the conductance of another conductor, called the standard, we have

$$C_s = \frac{C}{C_0} = \frac{l\Theta}{R_t d^2} \cdot \frac{r_T D^2}{L\Theta'} \qquad (4)$$

In Matthiessen's meter-millimeter standard the conductance C_0 is taken as unit conductance when $L = 1$ m, $D = 1$ mm and $T = 0°$ C., in which case $\Theta' = 1$. Substituting these values in (4) gives

$$C_s = \frac{l\Theta r_0}{R_t d^2} \qquad (5)$$

(5) is an expression for the conductivity by the meter-milligram standard of any round wire l m in length of diameter d mm, of temperature coefficient Θ and of ohmic resistance R_t ohms at temperature $t°$ C. When the standard is Matthiessen's standard r_0 is always equal to 0.0203 ohm. By definition $\Theta = \frac{R_t}{R_0}$, where R_0 is the ohmic resistance of the conductor at 0° C.

It is required, second, to find an expression for the conductivity of any conductor when referred to the meter-gram standard.

The mass of a length L of any conductor having a uniform cross-section S is $W = k'LS$, where k' is a constant. The ohmic resistance at temperature T of any conductor is

$$r_T' = \frac{kL\Theta'}{S}$$

where k is a constant and Θ' is the temperature coefficient. Placing the value of S obtained from the former expression in the latter gives

$$r_T' = \frac{kk'L^2\Theta'}{W} \qquad (6)$$

If, in the above, $T = 0$, $\Theta' = 1$, and if $L = 1$ and $W = 1$, we have

$$r_0' = kk'$$

$$\frac{1}{r_0'} = \frac{1}{kk'} = C_0$$

which is the conductance of a conductor of unit length and unit mass at 0° C. Replace in (6) the value of kk' by its value $\frac{1}{C_0}$ and we obtain

$$C_0 = \frac{L^2\Theta'}{r_T' W}$$

Similarly for any other conductor of length l, mass w, resistance R_t at temperature t and temperature coefficient Θ, the conductance of unit length and unit mass at 0° C. is,

$$C = \frac{l^2\Theta'}{R_t w}$$

As conductivity is the ratio of two conductances, we have

$$C_w = \frac{C}{C_0} = \frac{l^2\Theta}{R_t w} \cdot \frac{W r_T'}{L^2\Theta'} \qquad (7)$$

In Matthiessen's meter-gram standard the conductance C_0 is taken as unit conductance, when $L = 1$ m. $W = 1$ gram and $T = 0°$ C., in which case $\Theta' = 1$. Substituting these values in (7) gives

$$C_w = \frac{l r_0' \Theta}{R_t w} \qquad (8)$$

(8) is an expression for the conductivity by the meter-gram standard of any wire l meters in length, and of w grams mass, of temperature coefficient Θ, and of ohmic resistance R_t ohm at temperature $t°$ C.

When the standard is Matthiessen's standard, r_0' is always equal to 0.14173 international ohm.

It should be noted that in (8) neither diameters nor densities appear.

(5) and (8) give two ways of expressing the conductivities of conductors, according as the lengths and diameters, or lengths and masses are given. In the first instance the meter-millimeter standard is referred to, and in the second instance the meter-gram standard is referred to.

The conductivity being expressed by (8), the equivalent conductivity, as expressed by (5), can only be given when the density of the material is known.

To connect the expressions (5) and (8) write,

$$w = \frac{\pi d^2 l \delta}{4}$$

where δ is the density of the material, and the conductor is assumed to be of circular cross-section and of diameter d. Putting this value of w in (8) gives

$$C_w = \frac{4 l \Theta r_0'}{\pi d^2 R_t \delta} \qquad (9)$$

and taking the ratio of (9) to (5) we obtain

$$C_w = \frac{4 r_0'}{\pi r_0 \delta} C_s \qquad (10)$$

(10) gives the relation of the conductivities of the same conductor when referred to the meter-gram standard and when referred to the meter-millimeter standard.

Replacing in (10) the values in Matthiessen's standards for r_0' and r_0, which are, respectively, 0.14173 and 0.0203, we have the expression,

$$\frac{C_w}{C_s} = \frac{8.89}{\delta} \qquad (11)$$

(11) is very useful for connecting the conductivity when given in terms of the meter-gram standard with the conductivity in terms of the meter-millimeter standard, and vice versa, when the density of the material can be ascertained. Thus, if the conductivity of aluminium is given as 0.615 in terms of the meter-millimeter standard, and its density is taken as 2.7, then its conductivity in terms of the meter-gram standard is

$$C_w = \frac{8.89}{2.7} \times 0.615 = 2.025.$$

Bimetallic Conductors.

The relations which exist between the general and specific properties of bimetallic conductors are important to know in order to be able to estimate their money value and to make certain calculations respecting them.

Let Fig. 1 represent in section a bimetallic conductor, made up of a central core V and an external covering U.

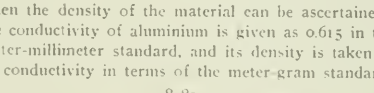


FIG. 1.—BIMETALLIC CONDUCTOR.

Let Θ', δ_2, S, l W_2 designate, respectively, the temperature coefficient, density, cross-sectional area, length and mass of the envelope U.

Let Θ, $\delta_1 s$, l W_1 designate the corresponding quantities for the core V. Also, let Θ'', δ_1, S_1, l W' designate, respectively,

the corresponding quantities for the bimetallic conductor, considered as a whole and which will be called Q. Let R_t be the ohmic resistance at temperature t of the length l of the bimetallic conductor. Put

C_s = conductivity of Q by meter-millimeter standard
C_s' = " " V " " " "
C_s'' = " " U " " " "
C_w = " " Q " meter-gram "
C_w' = " " V " " " "
C_w'' = " " U " " " "

By (5)

$$C_s = \frac{lr_0\Theta''}{R_t D^2} \tag{12}$$

where D is the diameter of the bimetallic conductor assumed to have a circular cross-section. Since the cross-section is,

$$S_t = \frac{\pi D^2}{4},$$

$$C_s = \frac{\pi l r_0 \Theta''}{4 R_t S_t} \tag{13}$$

The relation (13) holds if the bimetallic conductor is not of circular cross-section. By the principle of (8)

$$C_w = \frac{\beta r_0'\Theta''}{R_t W} \tag{14}$$

As $W = S_t\delta_t l$, we have also

$$C_w = \frac{lr_0'\Theta''}{R_t S_t \delta_t} \tag{15}$$

By (11)

$$C_s = \frac{\delta_t}{8.89} C_w \tag{16}$$

(12) and (13) are two expressions for the conductivity of the bimetallic conductor by the meter-millimeter standard; (14) and (15) are two expressions for the conductivity of the bimetallic conductor by the meter-gram standard, and (16) is an expression which connects the conductivity in terms of the one standard with the conductivity in terms of the other standard.

The conductivities, the densities, and the ratio of the cross-sections or weights of the component materials of the bimetallic conductor may be known, and it may be required, then, to calculate the conductivities of the compound conductor. The necessary relations for making these and other useful calculations may be obtained as follows:

Call r_t' the ohmic resistance of U and r_t the ohmic resistance of V both at temperature t. Then

$$\frac{1}{R_t} = \frac{1}{r_t'} + \frac{1}{r_t} \tag{17}$$

From (13)

$$\frac{1}{R_t} = C_s \frac{4 S_t}{\pi l r_0 \Theta''}$$

and by the same principle

$$\frac{1}{r_t'} = C_s'' \frac{4 S}{\pi l r_0 \Theta'}$$

and

$$\frac{1}{r_t} = C_s' \frac{4 s}{\pi l r_0 \Theta}$$

Placing these values in (17) gives

$$C_s = \frac{\Theta''}{\Theta\Theta'}\left(\frac{SC_s''\Theta + sC_s'\Theta'}{S_t}\right) \tag{19}$$

Since (19) is true for any temperature, it is true for the temperature of 0° C., at which temperature all coefficients are defined as equal to unity. Thus in (19) we can put Θ, Θ' and Θ'' equal to 1 when we have,

$$C_s = \frac{SC_s'' + sC_s'}{S_t} \tag{20}$$

It may be added that $S_t = S + s$.

If we equate (19) to (13), we get

$$R_t = \frac{\pi l r_0 \Theta\Theta'}{4\,(SC_s''\Theta + sC_s'\Theta')} \tag{21}$$

and if we equate (20) to (13), we get

$$R_t = \frac{\pi l r_0 \Theta''}{4\,(SC_s'' + sC_s')} \tag{22}$$

Again, we have from (14)

$$\frac{1}{R_t} = \frac{WC_w}{lr_0'\Theta''}$$

and by the same principle

$$\frac{1}{r_t'} = \frac{W_1 C_w''}{lr_0'\Theta'}$$

and

$$\frac{1}{r_t} = \frac{W_2 C_w'}{lr_0'\Theta}$$

whence by (17)

$$C_w = \frac{\Theta''}{\Theta\Theta'}\left(\frac{\Theta W_1 C_w'' + \Theta' W_2 C_w'}{W}\right) \tag{23}$$

By the same reasoning, whereby (19) changes to (20), we have

$$C_w = \frac{W_1 C_w'' + W_2 C_w'}{W} \tag{24}$$

By equating (14), first to (23) and second, to (24) we get

$$R_t = \frac{\Theta\Theta'\beta r_0'}{\Theta C_w'' W_1 + \Theta' C_w' W_2} \tag{25}$$

and

$$R_t = \frac{\beta r_0'\Theta''}{C_w'' W_1 + C_w' W_2} \tag{26}$$

In the expressions (21) and (25) the ohmic resistance at any temperature t of the bimetallic conductor may be calculated, if we know the temperature coefficients of each of the component materials, while in expressions (22) and (26) the temperature coefficient must be known of the compound conductor. Since to obtain temperature coefficients it is necessary only to measure the resistances at different temperatures with precision relatively, the coefficient, Θ'', may be obtained easily and without the use of accurate standards.

Again, if in (16) C_w is replaced by its value in (24) and W_1 by its value $\delta_2 Sl$, W_2 by its value $\delta_1 sl$, and W by its value $\delta_t S_t l$ or $\delta_t\ (S+s)\ l$, we obtain

$$C_s = \frac{S\delta_2 C_w'' + s\delta_1 C_w'}{8.89\,(S+s)} \tag{27}$$

Thus, if the conductivities of the component materials, in terms of the meter-gram standard are known, also, the densities of the component materials and the cross-section of each, the conductivity of the bimetallic conductor, by the meter-millimeter standard may be calculated by (27). It is necessary only to know the ratio of $\frac{S}{s}$, which, if we call this ratio q, gives in place of (27)

$$C_s = \frac{q\delta_2 C_w'' + \delta_1 C_w'}{8.89\,(q+1)} \tag{28}$$

The relations given in expressions (12) to (28) together with others which may be derived easily from them are sufficient for calculating resistances, conductances or conductivities of bimetallic conductors, expressed in either the meter-millimeter or the meter-gram standard, if the necessary data are given.

The Money Value of Conductors.

If the relative money values of the many types of electric conductors is to be ascertained, it is necessary to express the values of the different conductors in terms of one common unit of comparison. If one company gives the net price of 100 lb. of No. 8 copper, and another the net price of 1000 ft.

of No. 8 copper, no precise comparison is possible between these prices as they are listed. In the heterogeneous manner in which conductors are mostly listed it is generally puzzling and sometimes impossible (for sufficient data is not given) to compare prices accurately.

A conductor has value as a conveyor of electric power. It may possess additional value due to its tensile strength, lasting qualities, insulation, etc. But if the relative power conveying value of conductors is taken as a first uniform basis for ascertaining their relative money value, then, this having been done, it is easy to add or subtract a certain per cent value for other qualities which they may possess. If the electric power-conveying capacity, or what is the same thing, the conductance, per 1000 ft. or per mile, were taken as the one common basis for making a first comparison of the relative money value of conductors much uncertainty and confusion now existing would be ended. However, as the conductance of a conductor, or the reciprocal of its resistance, changes with the temperature, it does not make the best basis for the relative valuation of conductors of various kinds. We have a better basis in the product of the weight per unit of length by the conductivity in terms of the meter-gram standard. To show this, write,

$$\$ = \frac{K}{R_t} \qquad (30)$$

where \$ is the value in dollars of any conductor which has a resistance R_t at temperature t, and K is a constant.

From (8) we derive a value for $\frac{1}{R}$, which placed in (30) gives

$$\$ = \frac{KWC_w}{Fr'_0\Theta} \qquad (31)$$

As $\frac{K}{Fr_0'}$ is a constant, call it A and write

$$\$ = A\frac{WC_w}{\Theta} \qquad (32)$$

From this expression it is evident that the money value to the user of a given length of an electric conductor, when considered only as a conveyor of electric power, will increase directly as its weight and its conductivity, based upon the meter-gram standard. Its value will decrease as its temperature coefficient is greater. The value of the temperature coefficient, at a particular temperature, will vary but little for different conductors made of pure metals. The magnitude of the constant A will depend upon several factors, such as the units of length and weight chosen.

Expression (32) gives, however, a means of reducing to a common basis of comparison the value to the user of a given length of any conductor. We may take as the standard of value the market price of a given length and weight of copper. We can easily express then the value to the user of any other conductor, as one of aluminium, or bimetallic conductors, as compared with this copper conductor. The value to the purchaser will be the value of the conductor as a conveyor of electric power as compared with the value of a specified copper conductor. If the conductor considered has value additional to its power conveying capacity, such as superior tensile strength, then this must be separately considered and allowed for. But when the relative worth of a number of different types of conductors have to be considered, they should first be set off against one another in respect to their value as conveyors of electric power, and only after this has been done should claims to additional worth of various conductors be considered.

If we put as the value of a given length of copper conductor of weight W_1 and temperature coefficient Θ_1, and conductivity C'_w

$$\$_1 = A\frac{W_1C_w'}{\Theta_1} \qquad (33)$$

then comparing (32) and (33)

$$\$ = \frac{\$_1}{W_1C_w'}\,WC_w\frac{\Theta_1}{\Theta}$$

For all pure metals, the error for commercial purposes will be negligible if Θ_1 is taken equal to Θ and we may also with advantage consider $C_w' = 1$, then

$$\$ = \frac{\$_1}{W_1}WC_w \qquad (34)$$

In (34) if $\$_1$ is the market price in dollars of a given length of 100 per cent conductivity copper which weighs W_1 lb., then \$ expresses what W lb. of any other conductor of conductivity C_w is worth as compared with the above copper conductor. It must not be forgotten, of course, that (34) relates only to the relative power conveying value of the conductors.

It is concluded that the product, weight per unit length by conductivity on the metergram standard is the most satisfactory basis for comparing the relative worth of various electric conductors as conveyors of electric power.

In (30) we might have replaced the value of $\frac{1}{R_t}$ by its value derived from (5). Calling also S the cross-section of the conductor, $d^2 = \frac{4S}{\pi}$ and we derive finally

$$\$ = \frac{4K}{\pi l r_0}\cdot\frac{SC_s}{\Theta}$$

As $\frac{4K}{\pi l r_0}$ is a constant, call it B and write

$$\$ = B\frac{SC_s}{\Theta} \qquad (35)$$

Similarly for another conductor write

$$\$_{11} = B\frac{S_1C_s'}{\Theta_1} \qquad (36)$$

If it is assumed that the value (35) is compared with the value (36), the temperature and the length of the conductors being alike in both cases, also that $\Theta = \Theta_1$, and $C_s' = 1$, then we have an expression analogous to (34), namely,

$$\$ = \frac{\$_{11}}{S_1}SC_s \qquad (37)$$

In (37) if $\$_{11}$ is the market price in dollars of a given length of 100 per cent, conductivity (by the meter-millimeter standard) copper which has a cross-section of S_1, circular mils, then \$ expresses what any other conductor, of the same length, is worth when its cross-section is S circular mils and its conductivity (by the meter-millimeter standard) is C_s.

It would not be unreasonable to use (37) instead of (34) to express the relative values of different conductors in respect to their electric power conveying capacities, but as the product WC_w can be more easily determined than the product SC_s, the expression (34) is to be preferred. This is especially true in the case of stranded conductors where S cannot be determined precisely.

In arriving then at the relative money values of different electric conductors it becomes necessary to determine their conductivities on the basis of Matthiessen's metergram standard. We shall very briefly give the method of doing this, which theory and an extended experience shows to be the most rapid and the most accurate.

The Measurement of Conductivity.

The commercial measurement of conductivity involves the comparison of the unknown resistance of a low-resistance wire having a large temperature coefficient with the known resistance of a wire having the same temperature coefficient.

If the standard and sample wires are kept at the same temperature, and both have the same coefficient, the comparison may be made accurately without the actual temperature

being known. The apparatus best suited for the comparison of low resistances is the Kelvin Bridge, and it is this form of bridge, fitted with special reading scales, invented by Mr. Wm. Hoopes, which most generally is used for conductivity measurements.

The essential principles of the method are exhibited in the diagrams Figs. 2 and 3, the two arrangements shown being electrically identical.

It is required to measure the low resistance of a rod X in terms of the known resistance of a standard P. X is connected in series with P through the medium of a heavy copper connection E. r, p and r_1 and p_1 are ratio coils of large resistance as compared with X and P.

From the arrangement as exhibited in Fig. 2 it is evident that, if E were to have zero resistance and b and d came together, that $\frac{p}{r} = \frac{P}{X}$ or $X = \frac{r}{p} P$, for a galvanometer balance.

Theory shows that if the resistance of the yoke E is not negligible, then

$$\frac{P}{X} = \frac{p}{r} = \frac{p_1}{r_1}. \quad \text{Provided } \frac{p}{r} = \frac{p_1}{r_1},$$

as above, $X = \frac{r}{p} P$.

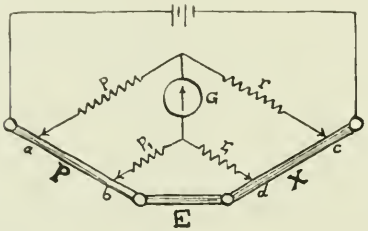


FIG. 2.—KELVIN BRIDGE

In practice r is made equal to p so $X = P$ for a balance.

Referring to Fig. 2, suppose that X is a rod of copper having a cross-section S. Suppose the scale I to have 100 equal divisions of arbitrary length between the points c and d. The resistance and its reciprocal, the conductance, of the rod X will depend upon the purity and the physical condition in regard to hardness, temperature, etc., of the copper of which it is made

Now suppose that P is also a rod of copper having a uniform, but not necessarily known, cross-section. Suppose the points a and b are separated until they include a length of the rod P which will have the same resistance as the resistance of the rod X of cross-section S, of 100 per cent conductivity, and of length equal to 100 divisions of scale I. This being done, the bridge will be balanced. Now, if no change is made in P or in the position of the contacts a and b, and we substitute

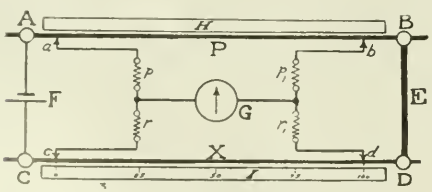


FIG. 3.—KELVIN BRIDGE.

for X another rod X' of the same cross-section but of less conductivity, it will then be necessary, in order to balance the bridge, to move the contact d towards the zero mark of scale I. Suppose the second rod X' has twice the resistance of X, or half the conductivity, then d will have to be moved for obtaining a balance half way down the scale I; that is, to the 50 division mark. Hence, in this case the 50 division mark indicates that rod X' has 50 per cent conductivity according to a standard based on cross-section.

Again, suppose we substitute for the rod X a rod X_1 which has 100 per cent conductivity, but twice the cross-section of rod X. In order to obtain a balance it will be necessary now

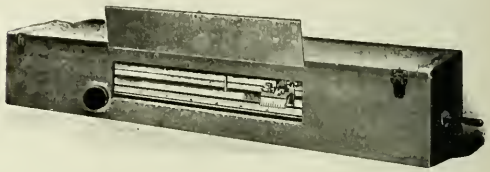


FIG. 4.—BRIDGE ENCLOSED.

to have the distance between a and b one-half what it was before. Then set b at the middle point of scale H. If now we substitute for X_1 a rod X_1' having the same dimensions, but of a lower conductivity than X_1, a balance will be obtained by moving d toward the zero mark of scale I and the reading of the scale will, as in the former case, give the per cent conductivity of X_1', which has twice the cross-section of the original rod X. Thus we may find a series of positions on the scale H corresponding to rods to be tested of various diameters or cross-sections.

Having a rod to test of a particular diameter, the slider b is set to a division on scale H coresponding to that particular diameter, then the reading on scale I gives directly, a balance being obtained, the per cent conductivity of the sample being tested.

The Kelvin bridge, fitted with the Hoope's scales, as above described, gives the conductivity in terms of the meter-millimeter standard. As this bridge is actually constructed by its makers at the present time, the standard scale H, Fig. 2, is laid off in weights instead of diameters, and the bridge readings are then given on the scale I in per cent conductivities based upon Matthiessen's meter-gram standard. The bridge

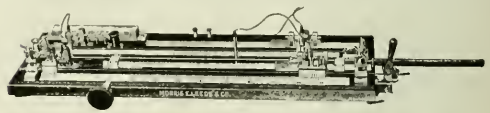


FIG. 5.—GENERAL VIEW OF BRIDGE.

gives by direct readings the values designated in this article by the symbol C_W, multiplied by 100.

In Figs. 4 and 5 are given views of Hoope's conductivity bridge, in and out of its enclosing case. In practice, it is always used in its case, which is lined on the inside with sheet metal to insure equality of temperature throughout its interior. The bridge measures the conductivities of wires from No. 0000 B. & S. to No. 18 B. & S. gage.

It may be supplied with different standards to take care of wires of different sizes, and various kinds. One standard covers a range of three wire sizes, B. & S. gage. The standard wires are made of the same material as the samples to be measured to insure an equality between the temperature coefficients of standard and samples.

An active person in a working day can measure conductivities to a precision of better than 1/5 per cent of 150 sample wires. The measurement involves these processes: Cutting off to a standard length and weighing the samples, setting the index on the standard scale to the weight of the sample to be measured, and balancing the bridge. When this balance is obtained the venier scale reads directly the per cent conductivity to 1/10 per cent, or better. More detailed descrip-

tions of this bridge and its accessories may be obtained from its makers, the Leeds & Northrup Company, Philadelphia, Pa.

Appendix.

In the following is given a summary of the more useful of the formulas which have been deduced. The formulas are lettered for ready reference, but the numbers, in parentheses following the formulas, are the same numbers given to them in the text.

The same symbols have the same meanings throughout, and are the same as used in deducing the formulas.

The numerical values given to constants assume that Matthiessen's metergram and meter-millimeter standards are referred to, where $r_o' = 0.14173$ and $r_o = 0.0203$.

The meanings of the symbols are restated for readiness of reference, and a numerical example is given under each case to aid to a clear interpretation.

In each formula where the conductivity appears, this is treated, in the example, as the unknown quantity. It is evident, however, that the formulas may be made to express the value of any single unknown quantity which they contain, when the remaining quantities in the formulas are given.

$$\text{(a)} \qquad C_s = \frac{0.0203\, l\, \Theta}{R_t d^2} \qquad (5)$$

or

$$\text{(b)} \qquad C_s = \frac{0.01594\, l\, \Theta}{R_t S}$$

C_s = conductivity by meter-millimeter standard, $100\, C_s$ = per cent conductivity by same standard.

l = length in meters.

d = diameter of a round conductor in millimeters.

S = cross-section of a conductor of uniform cross-section measured in square millimeters. If the cross-section is called V, and is in circular mils, write

$$S = \frac{V}{1973.52}$$

R_t = resistance in ohms of length l m at a temperature t degrees centigrade.

Θ = the temperature coefficient of the conductor considered, when this conductor is at a temperature of t degrees centigrade. The value of this coefficient will be different for conductors of different materials. It is nearly the same for the pure metals. Its value for copper can be found from a table given in the proceedings of the A. I. E. E., Vol. X, January, 1903, to December, 1903, page 25. Also this table may be found copied on page 18 of "Wire in Electrical Construction," published by John A. Roebling's Sons Company, Trenton, N. J.

For 20 deg. C. the value of Θ is given as 1.07968 for copper. Call it 1.08.

$$\text{(c)} \qquad C_s = \frac{31.457\, l\, \Theta}{R_t V}$$

V = cross-section of conductor expressed in circular mils.

$$\text{(d)} \qquad C_w = \frac{0.14173\, l^2 \Theta}{R_t W} \qquad (8)$$

W = mass of l m expressed in grams.

C_w = conductivity by Matthiessen's metergram standard.

$$\text{(e)} \qquad C_w = \frac{8.89}{\delta} C_s \qquad (11)$$

C_s = conductivity by Matthiessen's meter-millimeter standard.

δ = density of the material of the conductor.

$$\text{(f)} \qquad C_s = \frac{SC_s'' + sC_s'}{S + s} \qquad (20)$$

S = cross-section of covering and s = cross-section of core of bimetallic conductor.

S and s may be expressed as multiples of any unit, provided the same unit is chosen for each.

C_s'' = conductivity of covering and

C_s' = conductivity of core, both by the meter-millimeter standard.

$$\text{(g)} \qquad C_w = \frac{W_1 C_w'' + W_2 C_w'}{W}$$

W = the total weight of a given length of a bimetallic conductor.

W_1 = the weight of the covering and

W_2 = the weight of the core. These weights may be expressed in any units, provided the same units are used for all three.

C_w'' = conductivity of covering and

C_w' = conductivity of core; both by the meter-gram standard.

$$\text{(h)} \qquad C_s = \frac{q\delta_2 C_w'' + \delta_1 C_w'}{8.89\,(q+1)} \qquad (28)$$

q = ratio of the cross-section of the covering to the cross-section of the core.

δ_2 = density of material of covering.

δ_1 = density of material of core.

$$\text{(i)} \qquad R_t = \frac{0.01594\, l\Theta''}{SC_s'' + sC_s'} \qquad \text{See (22)}$$

Θ'' = temperature coefficient of the bimetallic conductor.

R_t = ohmic resistance in ohms at t degree centigrade of l m of the bimetallic conductor

$$\text{(j)} \qquad R_t = \frac{31.457\, l\Theta''}{V_1 C_s'' + v_1 C_s'}$$

V_1 = cross-section of covering of bimetallic conductor expressed in circular mils and

v_1 = cross-section of core expressed in circular mils.

$$\text{(k)} \qquad R_t = \frac{0.14173\, l^2\Theta''}{C_w'' W_1 + C_w' W_2} \qquad (26)$$

$$\text{(l)} \qquad \$ = \frac{\$_1}{W_1} WC_w \qquad (34)$$

$\$_1$ = the value in dollars of a weight, W_1, of a pure copper conductor of a given length.

W = weight in same units as W_1 of the same length of some other conductor whose electric power conveying value as compared with pure copper is sought.

\$ = value in dollars.

$$\text{(m)} \qquad \$ = \frac{\$''}{S_1} SC_s \qquad (37)$$

$\$_1$ = the value in dollars of a given length of pure copper conductor having a cross-section S_1.

S = Cross-section of same length of conductor whose value is sought.

Example (1).

A copper wire is 2 mm in diameter and 4 m long, and has a resistance at 20 deg. C. of 0.0223 ohm. By (a) its conductivity is by Matthiessen's meter-millimeter standard:

$$C_s = \frac{0.0203 \times 4 \times 1.08}{0.0223 \times 4} = 0.9876$$

or 98.76 per cent conductivity.

Example (2).

An aluminium wire is 1 sq. mm in cross-section and 2 m long, and has a resistance at 20 deg. C. of 0.05644 ohm. Calling its temperature coefficient at 20 deg. C., $\Theta = 1.08$, by (b) its conductivity is:

$$C_s = \frac{0.01594 \times 2 \times 1.08}{0.05644 \times 1} = 0.61$$

or 61 per cent conductivity.

Example (3).

The cross-section of the wire under example (2) is given in circular mils as 1973.52, then by (c)

$$C_s = \frac{31.457 \times 2 \times 1.08}{0.05644 \times 1973.52} = 0.61$$

or 61 per cent conductivity

Example (4).

An aluminium wire is 2 m long and weighs 50 grams. Its resistance at 0 deg. C. is 0.005585 ohms. Then $\Theta = 1$ and by (d) its conductivity by Matthiessen's meter-gram standard is:

$$C_w = \frac{0.14173 \times 4 \times 1}{0.005585 \times 50} = 2.03 \text{ or } 203 \text{ per cent.}$$

Example (5)

The density of aluminium is 2.7 and its conductivity is 0.615 by the meter-millimeter standard, then by (e) its conductivity by the meter-gram standard is:

$$C_w = \frac{8.89}{2.7} \times 0.615 = 2.0249 \text{ or } 202.49 \text{ per cent.}$$

Example (6).

A wire is made up of a steel core, having a conductivity by the meter-millimeter standard of 0.16 and an aluminium covering having a conductivity of 0.61. The cross-section of the core is 2000 circular mils, and that of the covering is 4000 circular mils. Then by (f), the conductivity of the duplex wire is:

$$C_s = \frac{4000 \times 0.61 + 2000 \times 0.16}{4000 + 2000} = 0.46 \text{ or } 46 \text{ per cent.}$$

Example (7).

A conductor has a steel core of conductivity by the meter-gram standard of 0.20, and an aluminium covering of conductivity by the meter-gram standard of 2. The steel core of a given length of the conductor weighs 10 lb., and the aluminium covering 8 lb. Then by (g) the conductivity of the conductor is:

$$C_w = \frac{8 \times 2 + 10 \times 0.2}{18} = 1, \text{ or } 100 \text{ per cent.}$$

Example (8).

In the conductor under example (7) the density δ_1, of the steel core is 7, and the density of δ_2, of the aluminium covering is 2.7. The ratio of the cross-section of the covering to that of the core would be, for the core chosen, $q = \frac{S}{s} = \frac{W_2 \delta_1}{W_2 \delta_2} = \frac{8 \times 7}{10 \times 2.7} = 2.074+$. Taking as in example (7) C_w', for the core, $= 0.2$, and C_w'' for the covering $= 2$. then by (h) the conductivity of the conductor by the meter-millimeter standard is:

$$C_s = \frac{2.074 \times 2.7 \times 2 + 7 \times 0.2}{8.89 \times (2.074 + 1)} = 0.4610$$

or 46.1 per cent conductivity by the meter-millimeter standard.

Example (9).

A bimetallic conductor 304.8 m long has a steel core 16.72 sq. mm cross-section and a copper covering 25.59 sq. mm cross-section. The conductivity by the meter-millimeter standard of the core is 0.16 and of the covering 1.00. If at 20 deg. C. the coefficient Θ'' is found to equal 1.09, then by (i) the resistance of this conductor at 20 deg. C. is:

$$R_{20} = \frac{0.01594 \times 304.8 \times 1.09}{25.59 \times 1 + 16.72 \times 0.16} = 0.1873+ \text{ ohms.}$$

If the cross-section of the covering, called C', and of the core, called C, are given in circular mils, then to calculate the resistance the formula (j) may be used to better advantage.

Example (10).

A bimetallic conductor is 1000 m long. The weight W_1 of its steel core is 180,000 grams, and the weight of its aluminium covering is 59,100 grams. The conductivity of the core by the meter-gram standard is 0.2 and of the covering 2.03. At 20 deg. C. its temperature coefficient is found to be 1.09. Then by (k) its resistance is:

$$R_{20} = \frac{0.14173 \times 1000^2 \times 1.09}{2.03 \times 59,100 + 0.2 \times 180,000} = 0.9903 \text{ ohms.}$$

Example (11).

Suppose that 100 lb. of a certain length of 100 per cent conductivity copper is worth $20, then by (1) 250 lb. of the same length of aluminium wire of 2.03 or 203 per cent conductivity, by the meter-gram standard, is worth:

$$\$ = \frac{20 \times 250 \times 2.03}{100} = \$101.50.$$

This is the value of the aluminium as compared with the copper wire when considered only as a conveyor of electric power. Equal weights of the same length of aluminium and copper have values, as conveyors of electric power, in the ratio of about 2 to 1.

Example (12).

Suppose that 100 ft. of copper conductor of 105,625 circ. mils is worth $64, then by (m) 1000 ft. of aluminium conductor of conductivity 0.6, by the meter-millimeter standard, and 133,225 circ. mils is worth:

$$\$ = \frac{64}{105,625} \times 133,225 \times 0.6 = \$48.44.$$

Equal cross-sections of the same lengths of aluminium and copper have values as conveyors of electric power in the ratio of about 6 to 10.

The Combustion of Producer Gas.

By Dr. Oskar Nagel.

High efficiency of combustion depends on thoroughness of the gas-air mixture, and on preheating the air. In order to obtain a temperature of bright red incandescence it is imperative to preheat the air for combustion by exposing it to the temperature of the hot products of combustion passing to the stack.

A good many devices for mixing the gas and air consist simply of two concentric pipes, one for air and one for gas.

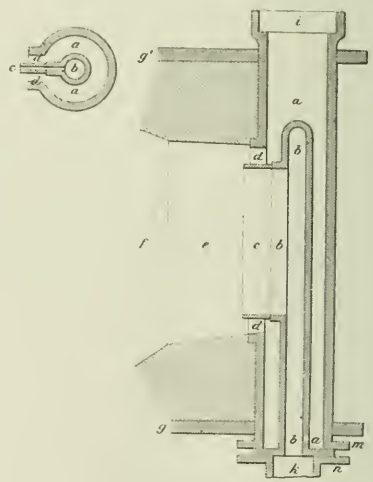


FIG. 1.—MIXING DEVICE FOR GAS AND AIR.

In Fig. 1 we have a gas pipe *a*, an air pipe *b*, a collar *c*; *d* is the opening of the gas pipe, *e* the flue, *f* the hearth, *g* the front plate of the furnace, g^1 the back plate, *i* the connection to the gas line, *k* the connection to the air line. *b* can be turned around its axis between the flanges *m* and *n* in order to give the flame the desired angle toward the hearth.

For a downward direction of the flame, the burner shown in Fig. 2 is very practicable; *b* is the air, *a* is the gas pipe.

The manner in which gas and air meet is of great importance for proper combustion. By a suitable arrangement of the gas and air channels a long or short flame can be produced. If air and gas are brought together at right angles (Fig. 3) a rapid,

concentrated combustion is effected. For every gas channel there is a corresponding air channel.

The arrangement shown in Fig. 4 effects a more rapid combustion as the gas rises toward the horizontal air current. The air, on account of its higher specific gravity, rapidly mixes with the gas.

If the currents of gas and air are carried parallel into the furnace, the combination of gas and air is gradual and a long flame is the result (Fig. 5). The flame is shortened if gas and air enter at an angle (Fig. 6).

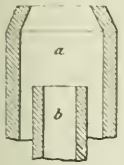
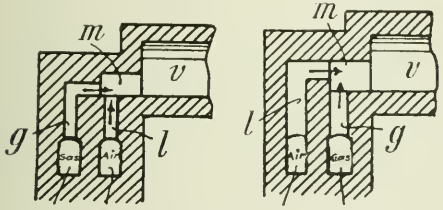


FIG. 2.—MIXING OF GAS AND AIR.

Another method is shown in Fig. 7. The air enters through slit *l* and the gas is blown through, drawing along a sufficient amount of air from *l*. Gas and air meet in *m* and are burned in *v*.

The small furnaces used in the metal industries for tempering and annealing are still generally heated by illuminating gas or other rich gases. However, they can also be used for producer gas, if the gas and air have a sufficiently high pressure. The temperature obtained increases with the pressure.

In order to obtain the highest economy in gas-fired furnaces where high temperatures are to be reached, successful use may be made of the principle of regeneration, i.e., of storing the waste heat in regenerators (heat storers consisting of chambers filled with firebrick checker work). It is evident that the gas and air currents must travel in a direction opposite to that of



FIGS. 3 AND 4.—MIXING DEVICES FOR GAS AND AIR.

the products of combustion, if it is desired to transfer the sensible heat of the waste gases to the incoming gas and air. It follows that a regenerative furnace consists of two symmetrical parts, the axis of each going through reversing mechanism. Each part consists of an air regenerator and a gas regenerator or of an air regenerator only.

The two air regenerators are connected by means of a reversing valve. Also the two gas regenerators.

Fig. 8 shows the plan of a regenerator system; *h h* are the air, *h'h'* the gas regenerators, *a* the air, *a'* the gas-reversing valve, *c* the gas main, *b* the opening for the air for combustion, *a* the stack. At the position of the valves shown air and gas travel to the left, combine in the flue above *c*, pass as flame over the hearth through the right-side regenerators and valves and leave through *d*.

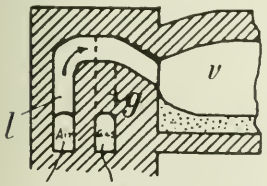


FIG. 5.—MIXING DEVICE FOR GAS AND AIR.

For comparison of direct firing with gas firing we show in Fig. 9 a directly fired furnace and in Fig. 10 the same type of furnace after its transformation to gas firing. First of all, we note the more convenient way of charging the fuel to the gas-fired furnace, the fuel being charged through a door *t* on top, while with direct firing the fuel has to be thrown in through the front door. The grate *r* carries in the first case a low bed of fuel and complete combustion to carbon dioxide takes place. In the second construction (gas fire) the grate carries a high bed of fuel and the effective gas is carbon monoxide.

In the first type of furnace the products of complete combustion heat the hearth and escape through the stack, in the second type the complete combustion takes place at the hearth, just where it is wanted, and the heat stored in the firebrick work below the hearth is utilized for preheating the air for combustion, passing through a flue *l* provided for this purpose. This comparison shows the greater convenience and higher economy of gas firing.

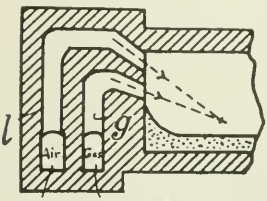


FIG. 6.—MIXING DEVICE FOR GAS AND AIR.

Electric Hardening Furnaces.

On page 95 of our February issue we described in detail the construction of the hardening furnace with electrically heated salt bath, built by the General Electric Company of this country. Former descriptions of the same type of furnace, as built in Europe, were given in our Vol. IV, page 667; Vol. V, page 428, and Vol. VI, page 419.

A great many details of the working of this furnace are given in a recent Faraday Society paper of Messrs. E. Sabersky and E. Adler.

The salt employed is usually a mixture of KaCl and $BaCl_2$, and Table I shows some of the materials used for different requirements. Current is transmitted to the bath by two electrodes made of Swedish ingot iron, which is characterized by a particularly low percentage of carbon, possessing a melting point of 1500 deg. C. to 1600 deg. C.

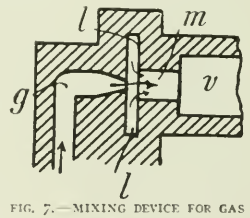


FIG. 7.—MIXING DEVICE FOR GAS AND AIR.

TABLE I.

Process.	Temperature.	Salts.
Tempering steel	200- 580°C	$NaNO_3 + KaNO_3$.
Annealing copper alloys, etc.	650- 900	NaCL or NaCl + KCl.
Hardening carbon steels	750-1,100	KCl + $BaCl_2$.
Hardening compound steels	1,050-1,350	$BaCl_2$
For special purposes requiring higher temperatures	1,500-1,600	CaF_2 or MgF_2.

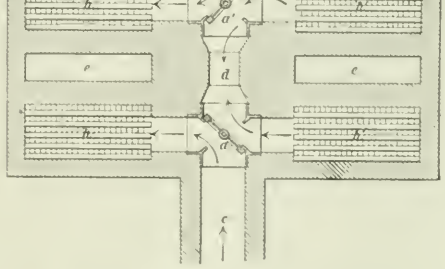


FIG. 8.—REGENERATIVE SYSTEM.

When all the salts have become melted, the voltage necessary for maintaining the temperature is about 5 to 30 volts, while the heating-up voltage reaches about 70 volts. Such low volt-

ges are not available from an ordinary supply systems and consequently a transformer has to be used.

It is arranged for any primary voltage up to 550 volts, while the maximum secondary voltage is about 70 volts. The secondary current is between 700 and 2800 amp in the different sizes of numerous furnaces.

The heat developed, and thus the temperature of the bath, are dependent on the voltage impressed on the furnace. If it is

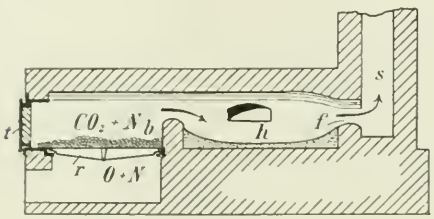


FIG. 9.—DIRECT-FIRED FURNACE.

desired to alter the temperature this can, therefore, be done by a variation of the voltage. The fact that a transformer is necessary makes the voltage control comparatively simple. Tappings are brought out from the primary winding of the transformer to a regulator switch, and thus the number of primary turns—that is, the ratio of the transformer—can be altered at will. This method of control, together with a tapping on the secondary side, gives 50 steps, which means 50 different temperatures, these being sufficient for most purposes. If as, for instance, in laboratory work, a still finer regulation is desired, a resistance is inserted in the primary which makes it possible to obtain up to, say, 500 steps. If the installation comprises a converter or a separate generator, a very effective means of voltage control is obtained by altering the exciter voltage.

An important part of the hardening installation is the pyrometer. For the temperatures in question the thermocouple type of pyrometer seems to give the most reliable results, but it has to be employed in a form suitable under the trying influence of the salt bath. In its latest shape it forms an angle,

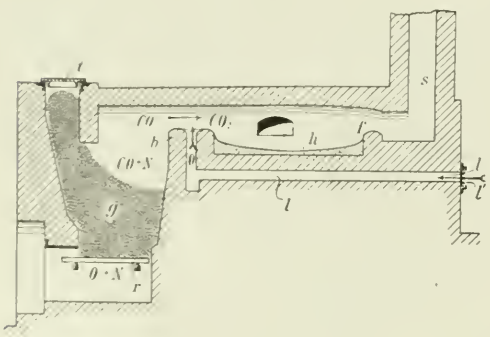


FIG. 10.—GAS-FIRED FURNACE.

the upper limb of which carries the terminals, these being thus outside of the destructive influence of the heat.

The thermocouple used is platinum, platinum-rhodium, protected by different protecting sheaths of Marquardt composition and steel. A steel cylinder protects the most sensitive part; that is, the one projecting from the bath. This part gets white hot, and unless protected against the oxidizing influence of the air would show signs of wear.

The e.m.f. of the thermocouple is read on a dead-beat moving-coil galvanometer, calibrated both in millivolts and degrees C., and reading up to 1000° C.

For ordinary purposes, and if the voltage remains fairly steady, the ammeter reading gives sufficient indication as to the temperature, and the pyrometer will only be used occasionally for checking.

On the basis of Robert Austin's well-known phase diagram the authors then consider the process of hardening. It consists essentially of two stages: First, the steel is heated up to a temperature corresponding to the state of martensite, i.e., a solid solution of carbon in a solvent of ferrite iron. The higher the temperature, the more evenly will the mixture be distributed, but if a certain temperature is exceeded the steel will, of course, be damaged.

The second stage is the fixation of the martensitic state by rapid cooling down. If the steel cools slowly, pearlite is formed and the steel becomes soft. But by means of rapid cooling we "freeze" the equilibrium corresponding to the higher temperature and fix the martensite state.

The remarks just made apply, of course, only to the binary solution of carbon in iron. If admixtures of chromium, tungsten, manganese or silicon, etc., are present, we get tertiary and quarternary alloys, and the phenomena become exceedingly complex. Some of these compound steels are self-hardening and owe the name to the fact that they will harden when heated up and allowed to cool slowly in the air, under which conditions ordinary carbon steel would deposit pearlite and become soft.

This phenomenon may perhaps be explained by a shifting of the transition line to lower ranges of temperature—thus, a condition analogous to the martensitic state being maintained at ordinary atmospheric temperatures. Compound steels, however durable and strong they may be, have the disadvantage that on account of their hardness they are extremely difficult to work. The modern trend of development in the manufacture of tool steels is to avoid true self-hardening steels and to adopt a compromise between self-hardening and carbon steels.

The active interest taken in tool steels since the demonstration of the Taylor-White material in 1900 has produced quite a number of steels going by various trade names and requiring a hardening treatment quite similar to that already described for carbon steels.

Each brand of steel possesses a certain hardening temperature to which it should be heated. This hardening temperature corresponds to that state which it is desired to fix permanently by the subsequent rapid cooling process. For compound steels it is 1005° C. to 1300° C. against 700° C. to 900° C. required for carbon steels. Generally speaking, the cooling process for compound steels cannot be so abrupt as for carbon steels. Instead of quenching the hot tool in water or oil, it is usually sufficient to expose it to a current of air or to dip it into tallow.

How any desired temperature for hardening may be obtained by selecting a mixture of different salts in proper proportion is shown above in Table I.

By dipping the cold steel into the heating chamber the temperature of the latter must drop—in fact, with gas-fired furnaces and salt baths it falls rapidly unless the tedious and uncertain procedure of increasing the gas supply is resorted to. In the electric furnace when the tool is dipped into the salt the level rises, the resistance of the bath drops, and current and heat increase automatically. Besides if it should be necessary to immerse large solid masses, the current supply can be easily increased by turning the regulator, thus preventing a drop in temperature. This point is of great industrial importance as it bears on the time in which a certain hardening process can be performed.

Another point which may be of great interest should be mentioned in this connection. In all types of furnaces, except

the electric, the thermal conductivity of the heating medium plays an important part. This medium fills the space between the tool and the heat producer and has to transmit the heat from producer to tool. In muffle furnaces heated by gas or electricity the heating medium is air. In furnaces with a metallic salt bath heated by gas, salt is the medium. The thermal conductivity of air or salt is low. Although the exact value of the latter has not yet been measured, it is safe to state that it is lower than the heat conductivity of iron. The steel can, therefore, transmit through a certain section in a given space of time much more heat than can be carried from the heat producer. The result is an inevitable drop of temperature.

In the electric furnace the heat is *produced* in the salt, not only *conducted* by it, and by increasing the voltage, more heat can be produced than the steel can take up. The speed with which the heating process can be performed is, therefore, not limited by the thermal conductivity of the heating medium and is in actual practice six to ten times higher than obtainable with other types of furnaces.

In the electric furnace the smaller cross-sections of the tool will, of course, also heat up quicker than the large ones, but will not overheat, because they cannot assume a higher temperature than that of the bath itself. The bath equalizes all differences in temperature, and in a very short time heats up the whole mass uniformly. This point explains the very small percentage of waste in electric furnace plants compared with others.

While the tool is in the bath, air is, of course, prevented from coming into contact with it, but a thin coating of salt protects it still further on its way to the cooling tank, and falls away only when placed in the cooling liquid. This is a great advantage over all types of open fires or muffles, but it is common to all bath-type furnaces.

Metal salts, however, offer the additional advantage that they do not give off poisonous gases, and that, unlike lead, they can be obtained comparatively pure at reasonable cost. Furthermore, a salt coating breaks up entirely in the cooling liquid, while with lead sometimes small particles stick to the steel leaving soft points underneath them.

During the heating-up period, or when a certain temperature is exceeded, the metal salts give off a small amount of vapor, and, therefore, hood and chimney are provided. During the normal operation there is scarcely any vapor at all produced. The hood offers the further advantage that the radiation of the bath surface is somewhat diminished, and can be made use of for preheating the articles to be hardened. For this purpose a grate is fixed in the hood on which the articles are placed prior to their being dipped into the bath.

An interesting case, in which the freedom of the electric furnace from smoke or vapor has been found valuable, is the hardening of rock-drills in a South African mine. Here the furnace is placed in a working, the drills are sharpened and rehardened underground, and a considerable saving effected all round.

Concerning the time required for hardening the following results of actual tests are interesting:

A milling cutter of 1355 grams weight (diameter 120 mm, bore 32 mm, width 25 mm) was heated from the temperature of the atmosphere to 1300 deg. C. in 128 seconds. When the same milling cutter had been preheated to 650 deg. C. (dull red heat), the further heating in the electric furnace from 650 deg. C. to 1360 deg. C. required 62 seconds.

A milling cutter of 250 grams weight (diameter 38 mm, bore 17 mm, width 45 mm) required 18 to 24 seconds to be heated from 650 deg. C. to 1300 deg. C.

A steel cylinder of 2250 grams weight, not preheated, required 243 seconds to be heated to 830 deg. C.

A comparison is also given of the comparative costs of the electric furnace and a gas furnace, from a test with 100 millers, each of 5.25 kg, with the following results:

Table II.

	Gas furnace.	Electric furnace.
Cost per miller	20 cents	6.8 cents
Time for total process	50 hours	10 hours
Cost per hour	40 cents	68 cents
Millers in furnace at one time	2	1

In other words, the enormous reduction of time required for hardening is at the bottom of the smaller cost of the electric furnace.

In many cases the hardening furnace has made it possible to substitute the rapid direct method for the tedious and costly case-hardening process.

In the discussion which followed the paper, Mr. F. W. Harbord described some of his experiences with the furnace in in heating a large number of steel bars from 800 deg. C. to 1230 deg. C. and keeping them at a high and fairly constant temperature for some time; this he was able to do without difficulty. If a furnace could be designed to compete with present large heating furnaces, its possibilities should be very great.

Mr. W. Rosenhain throught the furnace had decided advantages for the hardening and tempering of tool steels. He thought some care would be required in the selection of the fused salts; nitrates, for example, would have an oxidizing effect on steel. Too rapid heating of a piece of metal of uneven cross-section might be undesirable, as expansion stresses would be set up. The uniformity of temperature attained was probably largely due to lagging. He hoped that use of the furnace would throw light on such questions as whether heating to what are excessive temperatures when the metal is exposed to furnace atmospheres is also injurious when the metal is submerged in fused salts.

Mr. C. R. Darling criticised the author's figures for costs of working. In works in which producer gas was available for the gas furnace, the financial superiority of the electric furnace would disappear. He suggested the use of an optical pyrometer for temperatures above 1100 deg. C.

Mr. T. Vaughan Hughes considered that the electric furnace had many drawbacks compared with producer gas-fired equipments, such as too sudden heating, the trouble in dealing with fused salts, and the difficulties of handling large quantities of goods. He was of opinion, too, that its efficiency was low compared with existing furnaces, especially for maintaining comparatively low temperatures. He added some particulars of such gas-heated furnaces, which, he stated, easily realize the advantages claimed for the electric furnace, which, excepting for very precise and scientific investigations, could not compete with a properly designed producer gas-fired furnace.

Mr. W. C. Prebble remarked on the danger of suddenly heating complicated tools.

Dr. J. A. Harker thought that the amount of energy consumed in the furnace could be greatly reduced by improved lagging. The method of heating up the bath initially with a carbon rod seemed liable to difficulties. Had fused fluoride salts been actually used?

Dr. C. H. Desch considered that the furnace did away with the old difficulty of judging hardening by means of skill acquired with the eye. A pyrometer was of no use in an ordinary muffle.

Mr. E. Adler replied to the various points raised. The rate of heating depended on the voltage and was under control. No action of the fused salts on steel had been observed. Mr. Hughes admitted the scientific value of the furnace, but appeared to consider that scientific accuracy was unnecessary for scientific work. Of course, much larger furances than those now made could be built, and their efficiencies would increase accordingly. Optical pyrometers might perhaps be used above 1400 deg. C.; for ordinary purposes thermo-couples were pre-

terable. There was no difficulty in starting the furnace, which took some fifteen to twenty minutes. Fluoride salts had only been used experimentally.

Small Experimental Heroult Furnace.

By C. A. Hansen.

A year ago we built the furnace shown in the accompanying illustrations, Figs. 1, 2 and 3. It consisted merely of a couple of cast-iron flasks picked up from the foundry scrap heap, two trunnions originally belonging to a small ball mill, and two supporting cradles, such as are ordinarily used for holding ladles around a cupola. These were joined together and a spout—the only special piece made—was added to complete the tilting furnace chamber.

The electrode holders were likewise taken from the scrap heap—two old lathe tool slides. The furnace was kept in a vertical position by holding it up against a stop with a tackle. It was tilted forward by slackening the tackle. Quite recently we found an old tipping slag-car, appropriated the gears and we now have a convenient, respectable tool for experimental work.

To date somewhat more than 200 runs have been made on

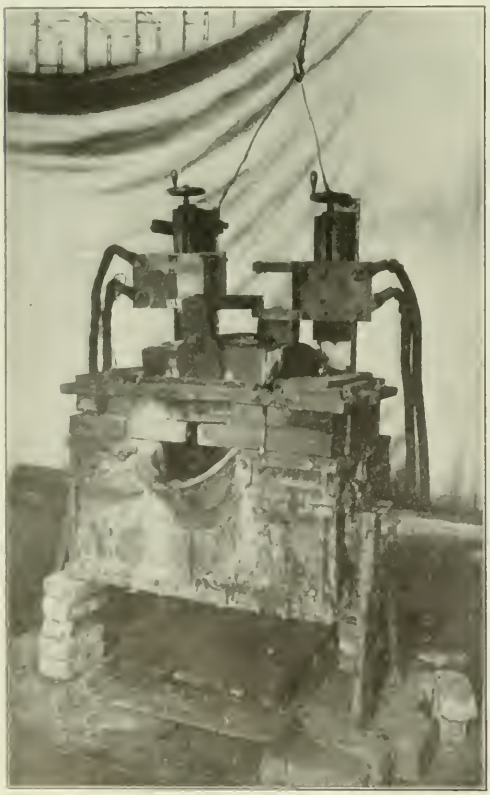


FIG. 1.—FRONT VIEW OF EXPERIMENTAL HÉROULT FURNACE.

very soft steels, high-carbon steels, high-speed tool steels, chrome steels, manganese steels and a variety of special alloys, the charges varying from as little as 50 lb. to 300 lb.

The furnace has been successfully used in experiments where fused ferrosilicon was used as reducing agent for a superimposed low-melting oxide slag. In short, we have been very well satisfied with the results obtained from the furnace, however small and crude it may seem.

Electrodes.

At first we tried 4 in. x 4 in. carbons as electrodes, but these were unsatisfactory for three main reasons:

1. The carbons available showed a decided tendency to chip off, or split off, at the hot end, especially at the start of a run.

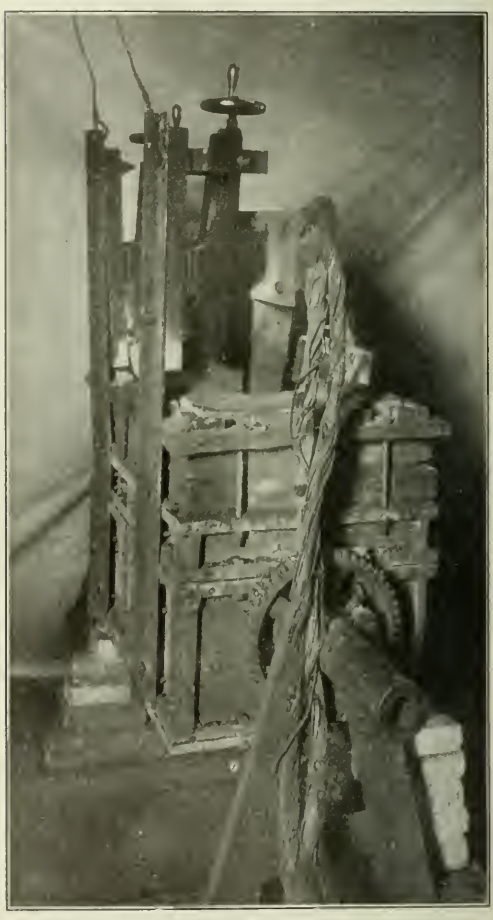


FIG. 2.—SIDE VIEW OF EXPERIMENTAL HÉROULT FURNACE.

In several instances one piece after another would drop off until in five or ten minutes the electrode would be too short to reach the bath. This very trying feature was almost entirely overcome by thoroughly drying the electrode and partially, at least, graphitizing the tip. If we put a layer of carbon in the furnace and passed current through it, we succeeded in both thoroughly drying out the furnace lining and in annealing the tips of the electrodes.

2. The furnace was not provided with cooling-water attachments and the poor heat conductivity of the carbons made for local heating at the terminal contacts. This objection could, perhaps, also have been done away with by proper terminal design.

3. Although in straight tensile pull the carbons are about twice as strong as graphites of equal section, they seem more

brittle and in several cases in tilting, and in puddling, when a puddle bar rammed into an electrode, the carbons broke off.

None of these troubles occurred when we used graphite, and it seemed that the saving in nerves and time balanced the very

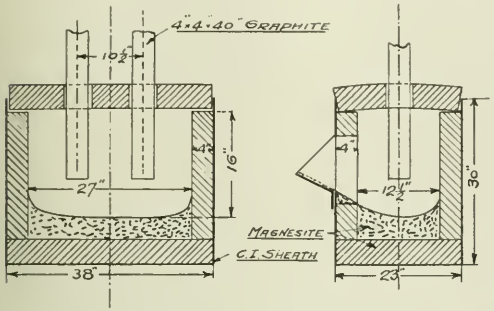


FIG. 3.—EXPERIMENTAL HÉROULT FURNACE.

much increased cost of the graphites. We have, therefore, used 4 in. x 4 in. graphite mainly.

Consumption of Electrodes.

This item has been rather large, due principally to the fact that the furnace was not as tight as it should have been so that considerable air circulated about the electrodes, and partly to the absence of water-cooling attachments which would secure a lower mean temperature of electrode and a consequently lower oxidation loss.

As regards relative consumption of carbon and graphite electrodes the results seemed rather in favor of the carbons. On the average the electrodes were shortened about 12 in. in four runs if unprotected, and 12 in. in six or seven runs if coated with a thin wash of carborundum and water-glass.

Power Consumption.

As regards power, Fig. 4 is reproduced. We were not at all limited in power supply and little precaution was taken to avoid bad power fluctuations. These curves, therefore, represent what happens with rough usage.

Fig. 5 shows the effect of a little care on the power curve. Only the most difficult portion of the run is tabulated in this case—melting a cold charge in a cold furnace. The vertical line drawn at 15 minutes, Fig. 5, represents the time when a bath was completely formed between the two electrodes. The only bad fluctuation on the curve was due to the addition of a

FIG. 4.—LOAD FLUCTUATION CURVES.

rather large ingot head which momentarily short-circuited the electrodes by raising the bath level.

A 150-lb. charge of sheet scrap can ordinarily be melted in a cold furnace with about 70-kw hours. The furnace can be kept hot with 50 kw and the power consumption per unit charge varies with the time it stays in the furnace. In one balance sheet, covering the melting and partial refining (carbon and sulphur) of 10,000 lb. of metal in 330-lb. charges, the power consumption averaged very close to 150 kw-hours per run, or 1000 kw-hours per ton. In at least half of these runs the furnace was perfectly cold at the start.

Each run was started with cold metal.

Metal Losses.

In the balance sheet above referred to I find we charged 10,000 lb. of metal.

We poured 8540 lb. of sound ingots.

Scrap on hand available for remelting, 980 lb.

Loss, 480 lb. = 4.8 per cent.

This loss would undoubtedly have been very much greater had we attempted to rake off slag for phosphorus removal.

Slags.

We attempted, naturally, to use an all-lime slag as in large-scale practice, but found that it invariably chilled at the base of the spout and hindered the withdrawal of metal from the

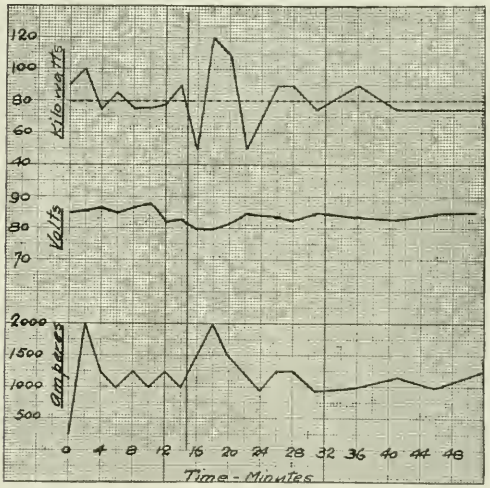


FIG. 5.—LOAD CURVES WITH CAREFUL OPERATION.

furnace. After some little experimenting we settled down to a 5:1 :: CaO : SiO_2 slag. This melted at a sufficiently low temperature so that it did not bother us much by chilling in the spout, and, although it was harder on the basic lining than the all-lime slag, we continued the use of it.

Linings.

The furnace was lined with a 4-in. course of magnesite brick, and this was covered to above the slag line with an inch at the sides, and with 2 in. to 3 in. at the bottom, of sintered Grecian magnesite, crushed to 40-mesh, and put in with a little water-glass. This tamped-in magnesite sintered to a dense, hard lining which, under ordinary conditions, lasted from eight to ten runs. The bricks with reasonable care last indefinitely.

The portion of the lining first attacked is that nearest the electrodes—the fluid slag whirls about with the electrode tip as a center and washes the lining away. A slightly larger chamber in which the lining could be withdrawn a few inches further from the electrode would undoubtedly increase the life of the lining immensely.

Quality of Output.

The following list of analyses covers the results in a dozen consecutive runs on alloy steel, in which the charge consisted chiefly of sheet scrap, averaging: Carbon, 0.2 per cent; sulphur, 0.05 per cent to 0.06 per cent; phosphorus, 0.05 per cent;

silicon, 0.10 per cent. manganese, 0.35 per cent. In general, slag was removed once and a second slag added.

	C.	P.	S.	Mn.
1	.13	.052	.014	.140
2	—	.019	.010	.076
3	—	.024	Tr.	.082
4	.082	.022	.012	Tr.
5	.067	.021	.012	.053
6	.098	.014	.010	.140
7	.125	.021	.026	.076
8	.071	.030	.026	.079
9	.129	.044	.007	.076
10	.094	.026	.008	.080
11	.130	.041	.013	.112
12	.088	.029	.013	Tr.

In making alloys we can generally come very close to the required analyses by adding the theoretical amount of material when neither metal nor both contains appreciable oxidizing matter For instance, several steels made up to contain 11.5 per cent chromium all analyzed between 10.8 per cent Cr. and 11 5 per cent Cr, which is certainly as close as one could reasonably hope for when working on so small a scale. The slag in these experiments analyzed 2 per cent to 3.5 per cent chromium and weighed about 12 lb. The metal weighed about 200 lb Obviously the loss of chromium is negligible.

In one experiment, however, the attempt was made to obtain a 5 per cent aluminium steel by adding Al. bar underneath the slag The analysis of the resulting metal gave 1.2 per cent. Al. and 4 per cent Si. The aluminium had reduced the silica in the slag. The composition required was obtained when alumina or calcium fluoride was used as flux for the lime instead of silica.

The following experiment is detailed to show the availability of the furnace for experimental work.

Two hundred pounds sheet scrap were charged, the bath was deoxidized with ferro-silicon, and the slag removed. A fresh slag was thrown on and fused, then the following additions were made to the neutral bath:

15 lb. FeC — 4 per cent C
5 " FeSi — 56 per cent Si
2 " FeMn — 80 per cent Mn
5 " FeP — 15 per cent P
2 " FeS_2

The log of the run which followed shows the removal of these impurities.

ANALYSES.

Time.	KW.	Additions (lb). Slag.	Metal Si	Mn.	S.	P.	C.
		10lb CaO 2lb SiO_2					
0	100						
10	100	Impurities	1.290	.888	.507	.369	.356
20	100		1.050	.578	.227	.336	.331
25	80	4lb Fe_2O_3					
30	80		.354	.380	.180	.346	.334
40	80		.103	.236	.140	.298	.216
		4lb Fe_2O_3 8lb CaO					
41	80						
55	80		.029	.163	.084	.103	.112
65	80	FeO-12.95% MnO-3.87%	.028	.135	.099	.203	.081†
66	80	6lb Fe_2O_3					
85	70						
86	70	6lb CaO	.004	Tr.	.107	.074	.063
	50	P_2O_5-3.76% FeO-28.82% MnO-1.41%	.026	.000	.101	.072	.05
105	50	6lb Fe_2O_3					
120	60		.007	.000	.089	.048	.060
135	0	10lb CaO 2lb SiO_2	.017	.000	.090	.050	.036‡
140	80	2lb FeSi					
150	80						
165	70	FeO-4.03% MnO-2.40%	.022	.000	.046	.034	.069
170	60						
175	60	2lb FeSi					
190	60	1lb FeSi					
200	60	CaO-37.95% SiO_2-38.81% FeO-8.71% MnO-1.35% S-0.56% MgO-12.74%	.253	Tr.	.045	.040	.032
220	60						
225	60	10lb CaO					§
230	60						
240	0		.200	.124	.047	.050	.034
Poured off							

*Neutral bath—200 lbs.
†Very little CO coming off.
‡Raked off slag.
§Glassy, green slag—does not disintegrate.
‖Disintegrating white slag.

I am indebted to Mr. B. R. von Sholly, of this laboratory, for the analyses.

The increasing phosphorus and manganese percentages at the end of the run show the result of leaving behind in the furnace some of the oxidizing slag. It seemed, however, to me that we removed it all.

In conclusion, I wish to point out the value of a furnace of this kind, which is well within the power range available at all of our technical schools, as a means of inculcating some, at least, of the principles of metallurgy. It is certainly evident that a few first-hand runs will do more toward fixing in one's memory the sequence of operations in metallurgy, and the reasons for them, than any amount of mere reading. An open hearth is practically out of the question for such a purpose.

Research Laboratory,
General Electric Company,
Schenectady, N. Y.

Dry Chlorination of Sulphide Ores.*

By F. W. Traphagen.

The use of chlorine in one form or another is not new to metallurgy, and this element has been the means of adding many millions to the world's store of wealth, chiefly through its use in chloridizing roasting for pan-amalgamation hyposulphite lixiviation and in the vat and barrel chlorination processes.

The proposed new process of dry chlorination of sulphide ores, which is just now attracting so much attention, is, however, totally different in principle from any of the above-mentioned processes, for while they require air in the preliminary operation of roasting, it is indispensable to the success of this new process that oxidation be prevented and the operation carried on so that chlorides are the only products formed.

Reference to the accompanying table will show how important this point is, for it must be borne in mind that the tendency, when chemical changes are taking place, is for those compounds to form which in their combination produce the maximum heats of formation. Furthermore, when conditions, especially temperatures are favorable, these tendencies are the more marked, the greater the differences between the heats of formation of the existing compounds and of those which may be formed by the recombination of the elements. Where the heat of formation of the possible new molecule is but slightly greater than that of the original molecule, the elements show but slight disposition to make new combinations, and the application of external energy is necessary to effect a change.

Keeping these points in mind we see from an inspection of the data in the table that the heat of formation of zinc chloride, for example, is more than double that of its sulphide, while the oxide possesses a value almost equal to that of the chloride.

In like manner the heats of formation of the sulphides and chlorides of the other elements are, respectively: Silver, 3000 and 29,000; cuprous salts, 20,300 and 35,400; cupric salts, 10,100 and 51,400; lead, 20,200 and 83,900; ferrous salts, 2400 and 82,200; manganous salts, 45,600 and 112,000.

HEATS OF FORMATION OF SULPHIDES, OXIDES AND CHLORIDES.

(Adapted from Richards' Metallurgical Calculations.)

	Sulphide.		Oxide.		Chloride.		
Metal.	Molecular Weight.	Heat of Formation.	Molecular Weight.	Heat of Formation.	Molecular Weight.	Heat of Formation. Dry in dil. sol.	
Gold	—	—	442.0	11500	303.5	22800	27200
Silver	248.0	3000	232.0	7000	143.5	29000	—
Copper (ous)	159.2	20300	143.2	43800	99.0	35400	—
Copper (ic)	95.6	10100	79.6	37700	134.6	51400	62500
Lead	239.0	20200	223.0	50800	278.0	83900	77900
Iron (ous)	88.0	24000	72.0	65700	127.0	82200	100100
Iron (ic)	—	—	160.0	195600	162.5	96150	127850
Manganese (ous)	87.0	45600	71.0	90900	126.0	112000	128000
Manganese (ic)	—	—	87.0	125300	—	—	—
Zinc	97.0	43000	81.0	84800	136.0	97400	113000

*A paper read at the fourth annual meeting of the Western Association of Technical Chemists and Metallurgists at Boulder, Col., Jan. 6, 1909; abstracted from the March issue of the *Western Chemist and Metallurgist*, the organ of the association.

The heats of formation in the above table are given in gram-calories per gram-molecurar-weight for each compound.

In carrying out the process care is taken not to pass in an excess of chlorine, so that only the protochlorides are formed. More energy is developed and the higher chlorides are formed when the partially chlorinated mass is discharged into water and treated with additional chlorine and steam. This brings all the metals into solution, when they are passed through filter presses with wooden frames and separated from the insoluble gangue and sulphur.

The metals may then be successively precipitated by displacement: gold and silver by copper; copper by lead, and lead by zinc. The reduced iron and manganese chlorides are perchloridized by steam and chlorine gas, and precipitated by zinc oxide. The solution thus freed from all the metals save zinc is evaporated to dryness and the resulting zinc chloride electrolyzed with the production of metallic zinc and the regeneration of the chlorine.

Theoretically about 22 lb. of zinc should be produced per hp-day; actual results have been somewhat better than half this figure, and with improved devices may be expected to reach as much as two-thirds of the theoretical figure.

The field of usefulness of this process is very large, but the most promising one is in the treatment of those ores that have so long been a source of anxiety to those owning them, i.e., the complex lead-zinc ores that could be marketed only by sacrificing one or more of the valuable constituents. The process is peculiarly adapted to the treatment of such ores, and the author looks to its development and success in that direction.

FIG. I.—CHEMICAL ENGINEERING BUILDING.

Like many other processes, this one is not new, and while Baker and Burwell, Swinburne and Ashcroft, and Alf. Sinding-Larson deserve much credit for their part in its development, they were far from being pioneers in the use of dry chlorine gas with ores, patents having been issued for this purpose as early as 1868.

DENVER, COLO.

Chemical Engineering at the University of Wisconsin.

The University of Wisconsin is one of the few engineering schools in this country offering four-year courses in chemical engineering, as companion courses to the older ones in civil, mechanical, electrical and mining engineering.

In 1895 a course in applied electrochemistry was organized at this institution, and three years ago this was incorporated into the newly established department of Chemical Engineering. Applied electrochemistry, being a branch of chemical engineering, is one of the several lines of work from which the students in chemical engineering have to choose.

The Chemical Engineering Building, the basement and first floor of which are devoted to needs of the chemical engineering department, is adjacent to the machinery building in which are located portions of the chemical engineering laboratories devoted to metal deposition and refining, storage batteries, electrolytic processes, electric furnace rooms, equipment for power generation, and rooms for experimental research work.

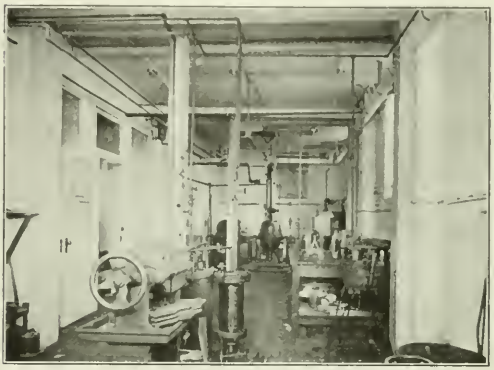


FIG. II.—LABORATORY OF INDUSTRIAL CHEMISTRY.

In the chemical engineering building proper are the class rooms, museum and reading room, offices laboratory for fuel and gas analysis, for the calorimetry and testing of fuels, for electrochemistry, metallography and chemical technology. One room is devoted to pyrometric standards and measurement, containing an extensive equipment of the various available forms of high temperature measuring instruments. The chemical technology laboratory is equipped with vacuum pan, vacuum and other drying ovens, condensers, digestors, filter presses, centrifugals, etc

One large alternating-current electric-furnace room is supplied with electrical energy from a two-phase, 200-kw alternator, and a direct-current furnace room has 100 kw available from a direct-current generator. Various other forms of electrical energy are also available.

The furnace equipment consists of various types of arc and

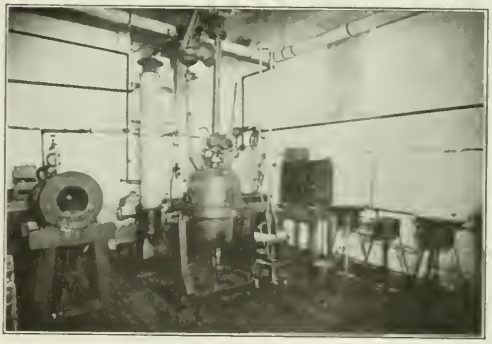


FIG. III.—VACUUM DRYING AND EVAPORATING MACHINERY.

resistor furnaces, muffle furnaces for roasting, gas fired melting furnaces, electrical transformers, regulating apparatus and instruments.

A room adjoining the furnace room is equipped with grinding, crushing and pulverizing machinery, including gyratory and jaw crushers, crushing rolls, buhrstone mill, ball mills, disk

grinders, also mixers, blower, sand blast outfit and magnetic separator.

Two rooms are devoted to plating and polishing of metals, two to the electrolytic refining of iron, and two to storage battery equipment, with several store rooms and research rooms.

These laboratories are designed for undergraduate instruction

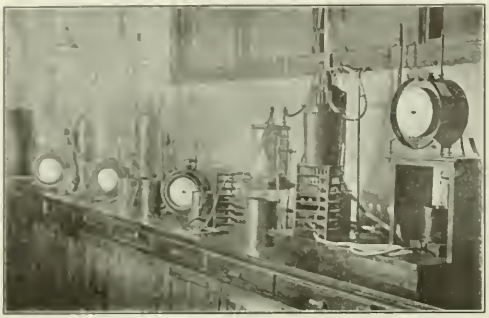


FIG. IV.—CALORIMETER LABORATORY.

work, and also for thesis and advanced research. Numerous lines of experimental work have been and are now under way, and some of these have resulted in the development of industrial methods. Work on the electrolytic refining of iron has been carried on continually for seven years, and several tons of refined iron have thus been produced. This iron is used most largely in the production of iron alloys, of which nearly 1000 have already been made, and about 500 of these have been machined into test bars for magnetic and other tests.

Among the more important lines of electric-furnace investigation may be named the production of molybdenum, of cerium,

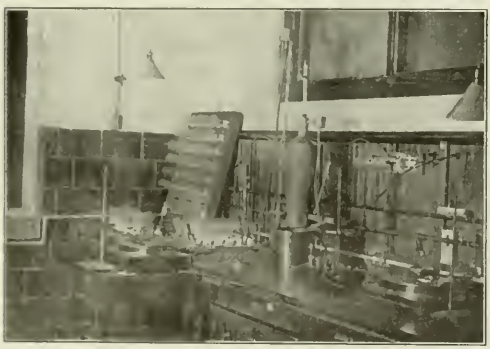


FIG. V.—TESTING EFFICIENCY OF A JUNKERS CALORIMETER.

a large number of borides and silicides, alloys of calcium with aluminium, magnesium, zinc, iron and other metals, the reduction of tungsten and the electrical reduction and distillation of zinc.

Extensive study has been given to the roasting of the zinc-iron ores for the purpose of magnetic concentration; the corrosion of iron has been systematically studied for a number of years, and special attention given to locomotive boiler corrosion as an electrochemical phenomenon. Pyrometers are being subjected to comparative tests and an investigation of the commercial efficiencies of gas heaters and various other gas appliances used in domestic work is now under way. An exhaustive study of various calorimeters for determining the heating value of gas was begun over a year ago, under the direction of a committee appointed by the American Gas Institute.

A considerable portion of the investigation work of this department has been devoted to a study of the problems presented to the Railroad Commission of Wisconsin in its supervision of the gas and electrical industries of Wisconsin.

Several hundred tests have been made upon dry cells and results of investigations along this line have resulted in various improvements which have been incorporated in the commercial product.

Provision is made for two courses of study—one of four years, leading to the Bachelor's degree, and one of five years, leading to the Chemical Engineer's degree.

These courses are based upon the idea that the chemical engineer requires a fundamental training in physics, in engineering

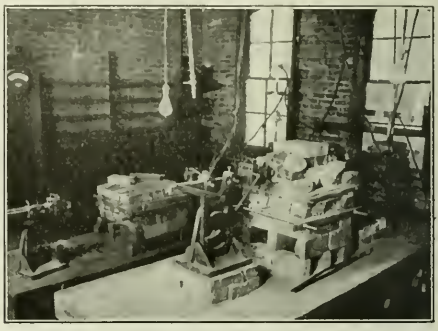


FIG. VI.—FURNACE-ROOM FOR DIRECT CURRENT.

and in chemistry, and while there is much discussion and difference of opinion expressed as to whether the chemical engineer be primarily a chemist or primarily an engineer, it is believed that the course as adopted gives such fundamental training in both lines that the student who has had such training is equipped to enter some of the various important lines of engineering work now coming under the classification of chemical engineering.

It is recognized that a four year's undergraduate course should be devoted most largely to a study of principles and

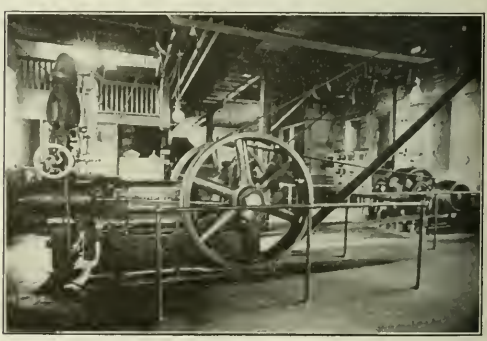


FIG. VII.—150-HP ENGINE AND GENERATOR FOR DIRECT-CURRENT FURNACES.

theories, rather than details of specialized lines, and it is not antagonistic to this idea that opportunity is given to certain elections on the part of students which may enable them to direct their attentions to certain groups of studies. A student who is especially interested and wishes to prepare himself for

electrochemical work may follow the outline of studies laid down in the electrochemical course, while as an alternative, a gas engineering or a metallurgical course may be followed by a suitable selection of subjects.

Under a grant from the Carnegie Institution of Washington an investigation of electrolytic iron and iron alloys has been carried on for four years.

By a recent decision the U. S. Forestry laboratories are to

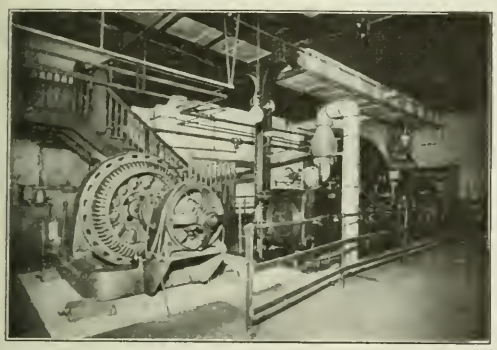


FIG. VIII.—250-HP ENGINE AND GENERATOR FOR ALTERNATING-CURRENT FURNACE-ROOM.

be located in Madison. These laboratories are to be placed in a large building to be constructed this year, and it is planned to provide a research force of 20 or more men. Much of this research work which it is proposed to undertake consists of the recovery of by-products in the wood-working industries and the utilization of wood and forest wastes, investigations which are of particular interest to the chemical engineer.

That there is a growing demand for chemical engineers is evidenced by the increasing number of requests which are being made for students having had this training. This demand for

FIG. IX.—FURNACE-ROOM FOR ALTERNATING CURRENT.

chemical engineers comes from a great variety of sources, including the chemical and other manufacturing industries, electrochemical, electric furnace and other similar lines of work; in metallurgy, in the cement and ceramic industries; in the manufacture and distribution of gas. This last is a particularly profitable field for those having chemical engineering training.

The Department of Chemical Engineering of the University of Wisconsin is under the direction of Prof. C. F. Burgess. J. C. Dickerman is assistant professor of chemical engineering. Dr. O. P. Watts, assistant professor of applied electrochemistry, has charge of the electrochemistry work, and Mr. O. L. Kowalke has the division of work relating to pyrometry, calorimetry and testing of fuels, and the manufacture and distribution of gas.

The Evaporator.

By Edward Zaremba.

In spite of the fact that evaporators are used in so many industries, the amount of knowledge in circulation concerning them is strikingly small. Thus it happens that the apparatus has reached a far higher stage of development in some industries than others.

At present the finest equipments are to be found in the German and Austrian beet-sugar factories. Similar excellence will be manifest in this country as soon as our manufacturers awaken to the necessity of reducing running expenses to a minimum.

The original evaporator was the old cast-iron kettle suspended over a fire, such as is still used in the woods for making

FIG. X.—FURNACE-ROOM FOR ALTERNATING CURRENT.

maple sugar; then came the open tank heated by interior steam coils. Equipment of this character is far more frequently used than should be the case at this late day. Its one advantage is low first cost; the objections are: (1) high steam consumption; (2) the creation of large quantities of vapor which will fill the operating room with fog; (3) large floor space required; and (4) high maintenance charges.

All these objections are eliminated by the use of vacuum

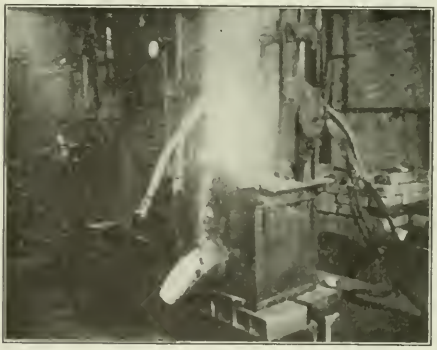


FIG. XI.—80-KW ARC FURNACE IN OPERATION.

apparatus. Where an open tank will demand a consumption of 1.2 lb. or more of live steam per pound of water evaporated, a single effect vacuum pan will do the work with 1.03 lb. of exhaust steam per pound of evaporation. In a double effect the steam consumption per pound of evaporation is reduced to 0.55 lb. and in the case of a triple effect to about 0.35 lb. Furthermore, the amount of condensing water required for a single

effect is reduced by 50 per cent in a double effect and by 65 per cent in a triple.

From one point of view a multiple effect consists of a series of boilers or bodies (two to five) whose heating medium is steam at successively lower temperatures for each succeeding body.

Again, a multiple effect is a series of surface condensers whose cooling medium (the liquor concentrated) is at successively higher temperatures for each preceding body.

Any given body can at any instant evaporate only so much water, or produce such an amount of vapor, as can be condensed in the steam-chest of its following body.

By feeding live or exhaust steam into the steam-chest of the first (high-temperature) body and connecting a vacuum pump and ordinary condenser (jet or surface) to the vapor space of the last (low-temperature) body the steam originally fed can be used as many times as there are bodies.

In plants running non-condensing engines and troubled by lack of sufficient power it is possible, by using a properly designed evaporator, to concentrate the liquor and at the same time have the evaporator act as a condenser for the engines; in other words, the steam can be taken into the evaporators at a vacuum of anywhere from 0 in. to 15 in. or still higher if need be.

The vacuum pan is the most efficient of all heat engines, the only necessary loss of heat being that by radiation, which will run from 5 per cent to 10 per cent in the case of uncovered pans—the low figure being for single effects, the high figure for triples.

Assuming that the workmanship in a vacuum pan is first class and that the heating tubes are ventilated without loss of steam, all forms of apparatus have practically the same steam economy, apart from the radiation loss, which, of course, would be dependent upon the amount of surface exposed.

There is an impression in some quarters that a multiple effect has more capacity than a single effect; this is a mistaken idea, as the function of the multiple effect evaporator is to increase the steam and water economy, not to increase the capacity.

Vacuum evaporators may be roughly divided into two general classes—the submerged-tube and the film type. In the former the tubular heating surface is entirely submerged in the boiling liquor, while in the later type the liquor is either showered over the hot tubes in a sort of continuous rain storm, or a mixture of boiling liquor and vapor globules is forced rapidly through the tubes.

In the submerged-tube type the steam is carried through the tubes with the liquor outside (horizontal tube apparatus), or the steam surrounds the tubes, with the liquor flowing upward through the latter (vertical tube apparatus).

The objection to the film type is its delicacy, being very apt to get out of order; furthermore, it is difficult to control the final density of the liquor. The main objection to the submerged-tube type is its comparative high first cost. However, when costs of operation and maintenance are taken into consideration they are found to be much cheaper in the long run.

A more or less elaborate equipment of pumps is required, the most important being the vacuum pump, which removes the non-condensable gases from the condenser. The tail pump removes the finished liquor from the final pan. The function of condensation pumps is to remove the condensed steam from the various steam chests working at less than atmospheric pressure. A circulating pump for the liquor concentrated is required in the case of certain film types using a forced circulation of liquor. In submerged-tube evaporators the circulation is automatically induced by the action of the vapor generated.

All forms of vacuum apparatus call for the use of a condenser, in which the vapor coming from the last pan is condensed by contact with cold injection water. In the wet system the air and gases present are entrapped in this warm mixture of condensed vapor and injection, the entire mass being withdrawn from the system by a wet vacuum pump and discharged.

In the dry system of condensation the condenser is made much larger and is mounted sufficiently high (about 34 ft.) to allow the water discharged to flow into the hotwell by its own weight against the pressure of the atmosphere. In this case air and non-condensable gases only are handled by the vacuum pump.

The term "barometric condenser" is generally used to signify a system similar to the dry system, except that the vacuum pump is eliminated by so constructing the condenser that air and other gases are entrapped in the outflowing water. As an offset to the omission of the pump the barometric condenser must be mounted considerably higher in order to secure the same results; furthermore, the water consumption is much greater.

As a rule the amount of water required varies from 25 lb. to 30 lb. per pound of vapor condensed. One of the great advantages of the wet system lies in the fact that such a condenser can generally be made to draw its own supply of injection from a neighboring stream or tank. The dry system always requires a circulating pump. There is a large supply of warm water at about 110 deg. Fahr. coming from the condenser, which can frequently be used to very good advantage. The first pan delivers a quantity of distilled water at 212 deg. equal to the amount of steam used; this is preferably returned to the boiler. From the condensation pumps another supply of warm water is obtained at a temperature between the two former.

The steam pressures ordinarily carried vary from 5 lb. down to atmospheric pressure; the vacuum from 23 in. to 27 in.

There are two ways of handling the concentrated liquor. One method, "batching," calls for the carrying of the concentration of the entire body of liquor in the final pan to the proper finishing density, after which the heavy liquor is removed by the tail (or magma) pump. In the other method, "continuous," the heavy liquor settling in the bottom of the final pan is withdrawn by the pump while the pan continues in operation.

The multiple-effect evaporator, although seemingly mysterious in its action, if properly designed, is easily operated—the work being generally performed by unskilled labor. The chief care of the operator should be to preserve the greatest possible uniformity of conditions as concerns the pressure of steam, height of the vacuum, rate of liquor inflow, and the drainage of the steam chest. As soon as he has become familiar with these points the rest is a mere matter of routine; henceforth the evaporator should require very little attention. A good evaporator is like an excellent employee—the less watching and interference the greater the results produced.

A New Norwegian Calcium Carbide and Cyanamide Works.

The large amount of water power available in Sweden and Norway has resulted in recent years in the establishment of numerous new industries. According to recent estimates, the following amounts of water power are available and partly developed:

	Available.	Developed.
Sweden	4,000,000 hp.	400,000 hp.
Norway	5,000,000 "	500,000 "

The figures given under "developed" refer to plants actually in operation or in course of construction.

Owing to the widely differing conditions, the hydro-electric plants are of very different types, suitable for heads from less than 3 ft. up to 3290 ft., and to deal with quantities of water up to 9900 cu. ft. per second. Our excellent London contemporary, *Engineering*, has recently published in the numbers of March 12 and 19, some interesting illustrated descriptions of five different typical plants.

From these articles we have extracted the following figures, which are particularly interesting with respect to the cost of

power development. The first three figures under "cost per electric hp" are actual costs, the plants being finished. The last two figures are estimated costs, but believed to be approximately correct, the plants being not yet completed.

	Turbine hp	Feet head	Cost per electric hp.
Joesefors, Sweden	1,800	26	$70
Frykfors, Sweden	4,000	27	64
Yngeredsfors, Sweden	8,250	60	38
Vamafos, Norway	75,000	86	26
Tya, Norway	73,000	3290	36

The last two plants are particularly interesting to electrochemical engineers. The Vamafos plant belongs to the company exploiting the Birkeland-Eyde process, and the Tya plant to the Badische Anilin und Soda Fabrik. Both plants are to be used for the fixation of atmospheric nitrogen. As was mentioned in our last issue, page 147, the Birkeland-Eyde concern has reached an understanding with the Badische Company and the results to be obtained at the experimental plant at Notodden in comparative tests with the Birkeland-Eyde process and the new process of the Badische Company will decide which of the two processes is to be finally adopted for large-scale manufacture.

In its issue of March 26 and in following issues, London *Engineering* describes in greater detail another Norwegian hydro-electric plant, situated at Odda, on the Sondrefjord, for the manufacture of calcium carbide and cyanamide.

The erection of these works has had considerable influence on the prosperity of the district in which they have been established. Odda, at the top of one of the most beautiful fjords, was formerly merely a resort of tourists. The tourist season, however, is short, and the measure of prosperity resulting from passenger traffic very limited. Now, however, the population has multiplied threefold; an air of unobtrusive prosperity permeates the district, and influences also a wide area, owing to the increased demand for food, fruit and other supplies.

Those responsible for the design of the carbide and cyanamide works, too, have taken precaution not to materially injure the amenities of the district, and have, for instance, as a result of many experiments, introduced the sprinkler system for dealing with smoke and other products of combustion from the carbide furnaces.

The works were originated by an English company, organized to manufacture and sell a special acetylene plant designed for a dry process. When they had perfected their system, they discovered that a serious obstacle to the commercial development of the scheme was the uncertainty of the supply of calcium carbide.

They succeeded in demonstrating that with carbide at a reasonable price villages, country houses, isolated railway stations, railway carriages, and dock, tunnel and other such engineering works in progress would be illuminated with acetylene at a less cost than would ordinary coal-gas, alike in capital and working charges. But few cared to incur even the small capital outlay involved in the acetylene-generating plant, with an insufficient and in some measure uncertain supply of carbide.

Mr. A. E. Barton, who was at the head of this acetylene company, entered into the negotiations for the purpose of combining several undertakings, including the Alby works in Sweden, and for the construction of new works on such a scale as to ensure a continous and cheap supply of carbide.

Odda was selected not only because of its convenience of approach from the sea, but because of the proximity of a waterfall owned by the Aktieselskabet Tyssefaldene, and suitable for the generation of electricity which enters largely into the cost of manufacture. A hydro-electric power installation has been constructed to give 23,000 electrical hp, although the available water makes 75,000 hp to 80,000 hp possible of realization when required.

Carbide works have been organized, and a cyanamide factory added, in order to convert the carbide into calcium cyanamide (trade name "nitrolim") for use as a fertilizer. The total producing capacity of the works is 32,000 tons of calcium carbide and 12,500 tons of nitrolim per annum.

Every effort has been put forth not only to ensure uniformity of results, but the highest economy, and, consequently, the establishment represents the most modern practice in this branch of electrochemistry. This success in manufacture depends upon three factors.

The first, concerned with the ensurance of absolute uniformity in production, requires the selection of the purest raw materials. The anthracite, from which the carbon is obtained, is specified to have not more than 3 per cent of ash; and the limestone must have as little as possible of magnesia and alumina. The coal used is got from Wales and the limestone from the quarries which the company have purchased because of the suitability of the stone, situated at Skaterun, near Bergen, and Levanger, near Trondhjem. In addition, the company owns quarries elsewhere in Norway. Both the raw materials, as well

FIG. 1.—TYPICAL VIEW OF TYSSE RIVER AND COLLECTING AREA.

as the gas-coal for firing the limekilns, are brought by water transport to Odda.

The second and still more important of the desiderata is to obviate any great variation in the temperature in the electric carbide furnaces. These furnaces are worked at from 2800° C. to 3000° C., equal to 5300° Fahr to 5270° Fahr.

The third element is economy. Each furnace is of 1400 kw capacity and gives from 7 to 8 tons of calcium carbide per day of 24 hours. Cheap electricity is a primary essential, and this has been achieved by the hydro-electric installation.

Again, each ton of carbide manufactured involves the use of about 2000 lb. of calcined lime and 1300 lb. of anthracite. The supply, transport, and particularly the handling of this material at works where operations are carried out, as at Odda, on a large scale give opportunity for ingenuity in devising conveying facilities.

A system has been worked out for handling the materials as nearly completely automatically as possible.

A careful analysis was made of the cost of unloading the coal and lime and of transporting it by cableway to silos about

1000 yd. distant, where it is stored, in order that the squad of men employed might be paid on the premium system. The standard rates evolved from this analysis work out at 35 ore (about 9 cents) per ton of limestone, 45 ore (12 cents) per ton of anthracite coal, and 40 ore (11 cents) per ton of gas-coal. In a day of 10 hours as much as 300 tons have been unloaded, conveyed by cableway and discharged into the silos, the men employed including two cranemen and 27 laborers at the wharf and one at the silos. One man's time suffices for the transport of the material from the hopper-doors of the silo into four out of the five kilns (one is a stand-by) which are in operation, the rate of combustion being a total of 190 tons per day of 24 hours in the four kilns.

The limestone cars work on the level by electric traction, and up the incline to the charging platform of the kiln by cable haulage. They only need to be filled at the silo-hoppers and sent on their way, each being automatically tilted at the kiln for which its contents is destined, by reason of the tipping gear differing for each kiln. The same economy of labor characterizes each operation in the whole process of manufacture.

The calcined lime and the anthracite coal are similarly conveyed in buckets, having electric motors, traveling on a Telfer railway to the electrically operated breakers adjacent to the electric furnaces. The ladles with the carbide from the furnaces are taken by overhead rail to the cooling house, and thence by conveyors to the breakers and sifters, which, discharging through hoppers and shoots, enable the finished material to be loaded into export tins according to the size of the cubes. From first to last the only handling is in charging the electric furnaces, a work which is not mechanically done, as the best results are got by the manual distribution of the material.

Electrically worked conveyors are similarly used in the cyanamide works, where the principal operations consist in the separation of nitrogen from atmospheric air by the Linde process, and the subsequent reaction between the nitrogen gas (which must not contain more than 0.4 of oxygen) with calcium carbide in electric furnaces, whereby calcium cyanamide is formed, containing 20 per cent of nitrogen.

The furnaces are of 1-ton capacity per week, taking at each charge one-third of a ton, and are worked at a temperature of 800° C. to 1000° C. (1470° Fahr. to 1832° Fahr.). The furnaces are portable and are moved to the charging position by overhead crane.

The resulting cyanamide is reduced to powder in electrically operated crushers and distributed by elevators and conveyors to the silo—a building 164 ft. long, 131 ft. wide and 20 ft. 6 in. high. Like the calcium carbide, it is packed mechanically for export. The oxygen, obtained by separating the nitrogen from the air by the Linde process, is also marketable, and it is proposed to have a plant for the manufacture of sulphate of ammonia from by-products.

The source of hydraulic power for the turbines is the River Tysse, which flows into the Sondrefjord at a point four miles from Odda. The Tysse is a typical river of western Norway. Its source is the dark Ringedalsvand, or lake, whence it flows surging and leaping through wild and narrow ravines, having a fall of 436 m (1430 ft.) in a distance of about four miles. The Ringedalsvand is the natural regulation basin for the largest part of the rain-collecting area, which is mainly situated on the highlands of the Hardangervidden, about 1000 m to 1200 m (3280 ft. to 4000 ft.) above sea-level, the higher points and valleys being in the region of eternal snows.

Fig. 1 gives a typical view of the Tysse River and Fig. 2 a plan of the works; they are also reproduced from the London *Engineering*.

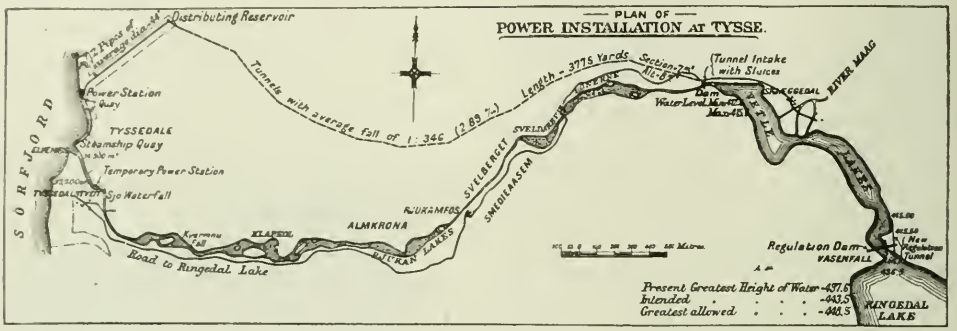


FIG. 2.—PLAN OF TYSEE POWER DEVELOPMENT.

The collecting area is 380 sq. km (94,000 acres), made up of small valleys forming rows of lakes or gorges with bare, rugged rocky slopes. A shower of rain thus forms hundreds of brawling, rushing streams, which ultimately discharge into the Ringedalsvand, 5.5 sq. km (1360 acres) in area, and with a summer water level of 436 m (1430 ft.) above sea level. There is only a distance of 3.5 km (2 miles) as the crow flies from lake to fjord, where the power station is located, so that the conditions were favorable for the construction of a pipe line to the power station.

In calculating the possibilities of power output the annual rainfall was assumed as 2.5 cu. m per meter area, which gave

FIG. 3.—POWER HOUSE.

from the complete area an average yearly supply of 1000 million cu. m (35,317 million cu. ft.), or 25 cu. m (833 cu. ft.) per second. Observations in 1906-7 gave the average flow per second as 30 cu. m, and for 1907-8 as 26 cu. m with a loss of 20 per cent by evaporation, etc.

The higher rate in the former year was due not so much to the rainfall as to the higher temperature during the summer whereby the quantity of snow melted was greatly increased. Therefore 25 cu. m per second seems a fair average.

For the present 6 cu. m (212 cu. ft.) per second sufficies to

maintain the output at the required capacity of 23,000 electrical hp, developed by the five generators of equal capacity. But it would be quite possible by augmenting the storage capacity, and by adding to the number of supply pipes and turbo-generators, to get sufficient water power (20 cu. m per second) to develop 75,000 or 80,000 electrical hp.

In Norway, as in Switzerland, it is during the winter months that there is difficulty in maintaining the supply of water. During the winter the fall consists of snow, and the lakes are frozen from November to June.

To enable the water to be drawn from the Ringedalsvand when it is frozen over a regulation tunnel has been formed having its inlet about 16 m (52 ft.) below normal water level. This short tunnel discharges into the lower lake, from which the water passes to the tunnel and pipes to the power station. There is thus maintained a supply at seasons when little water is flowing over the regulating dam between the lakes. This tunnel is 160 m (525 ft.) long.

For the further regulation of the water level in the Ringedas lake a dam was built across its outlet with its crest 448.5 m (1470 ft.) above the sea. It is of the following measurements: Length, 280 m (918 ft.); height, 16 m (52½ ft.); breadth at top, about 2.25 m (7 ft. 4 in.), and at the base about 12 m (39 ft.). The level of the lake is thus raised to increase the storage capacity by about 160,000,000 cu. m. The main dam is, however, at the foot of the Velte Lakes, where also is the inlet to the main tunnel for supplying pressure water to the turbo-generators.

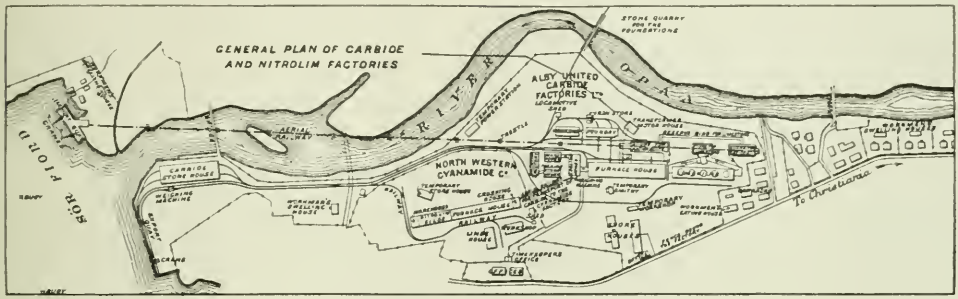
The tunnel from Velte Lake discharges into a basin constructed at the top of the precipitous slope down which the pipes have been laid. This basin is oblong on plan and is 18 m (59 ft.) deep, the bottom being on the same level as the tunnel outlet, 397 m above the sea, while the top is at the same height as the crest of the dam at the Velte Lake. In this way there is avoided any great overflow from the basin in the event of the turbo-generator coming to a standstill, as the water would ultimately flow over the dam at the lake.

The pipe lines have each been designed to supply sufficient water to three turbines, of a total water consumption of 3.6 cu. m (127 cu. ft.) per second. The construction of the line was necessarily a difficult undertaking, because of the steep gradient. The incline, indeed, is probably the greatest in the case of any pipe line, one section, 160 m (525 ft.) in length, being at an angle from 45 deg. to 55 deg. Three-quarters of the line was too steep for the workmen to ascend and descend without the aid of ropes.

The power station, as shown in Fig. 3, is constructed close to the water level, with sufficient room for extension on the north side. The building, as at present completed, is 50 m (164 ft.) long, and 11 m (36 ft.) wide, and has a large engine room accommodating the six generators now installed. There is adjacent to the power station an import quay, with an overhead crane. From this quay a railway track runs into the main engine room of the power station.

There are six turbo-generators in a row in the center of the engine room. Each unit is arranged with its axis across the hall, the turbines being to the right and the dynamos to the left. The water enters beneath the floor from the right through the different valves, and leaves the turbines through the tail-race, which is under the floor level and between the foundation piers for the dynamos. The turbines are of the Pelton wheel type, with automatic regulation, on a design by Messrs. Escher Wyss & Company, of Zurich.

The dynamos are by the Almanna Svenska Elektriska, A. B. Westeras, Sweden, and work on the three-phase alternating system, with a tension of 12,000 volts and a frequency of 25 periods. They run at 375 r.p.m., developing 4600 hp, and the output of the generators is 4400 electric horse-power.


GENERAL PLAN OF CARBIDE AND NITROLIM FACTORIES
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NORTH WESTERN CYANAMIDE Co
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FIG. 4.—PLAN OF CARBIDE AND CYANAMIDE WORKS.

FIG. 5.—VIEW OF CARBIDE AND CYANAMIDE WORKS.

Each turbine is coupled direct to its corresponding generator, and five sets run synchronously to produce 20,000 hp at the terminals of the switchboard at the carbide factory at Odda. The sixth set is kept in reserve. Two exciters are installed at the north end of the station, which give 200 electrical horsepower when working at 24 revolutions, the voltage being 100.

The current is transmitted to Odda, four miles distant, at 12,000 volts.

Fig. 4 is a general plan of the carbide and cyanamide factories, while Fig. 5 gives a view of the works, showing from left to right the Sondre Fjord, Odda, the cyanamide silos and furnaces, the carbide furnaces, and the lime kilns.

On the banks of the fjord there has been constructed of timber an import quay, which is entirely independent of the export wharf. Alongside the quay there is a depth of water of 22 ft. at low water, the rise and fall of the tide at this point (110 miles from the sea) being 6 ft. to 9 ft. At this wharf, which is about 50 m (164 ft.) long, there are two cranes, the lifting power of each being 2 tons.

The material raised from the holds of the ships by the cranes is deposited into hoppers, from which tip-wagons are filled, and are then run on the quay level to the cableway station, where the wagons are automatically weighed and afterwards automatically gripped to the cable on the aerial railway.

This cable railway extends from the quay along the course of the Riven Opaaen, and through the works to three silos, arranged respectively for the storing of 2000 tons of anthracite, 2000 tons of limestone, and 1500 tons of gas-coal. The wagons are passed from the aerial cableway to a telpher railway, extending along the top of the three silos, and provided with movable tipping levers, so that the workmen at the silo can arrange for the automatic teeming of the contents of each car into any of the hoppers of any of the silos.

The limestone cars may also be shunted to a sliding over a reserve bin, as shown on the plan, Fig. 4. The silos are arranged with hopper-bottoms, chutes and doors at frequent intervals.

The material, when required for the manufacture of calcium carbide, is filled into cars running on a telpher track, and having their own electric-traction motors. Current is taken from the overhead conductor, which is divided into circuits coincident with the distance between the hopper-doors, so that the workman, when he has released the contents of the silo-hoppers into the car, may switch on the current to enable the car to travel either to the producer in the case of the gas-coal, to the kiln in the case of the limestone, or to the anthracite hopper, in communication with the breakers, in the case of coal for the carbide furnaces.

The charging platform of the lime-kilns is at a high level, and cable traction has been adopted for the gradient. The calcined lime is similarly conveyed by electric cars on a telpher railway from the discharge doors of the kilns to the mixing room, which forms part of the electric-furnace house.

Here the two main constituents of the furnace charge—lime and anthracite—are automatically weighed in double-compartment wagons, mixed, and lifted to the charging platform of the electric furnaces. As already explained, the furnaces are charged by hand, as this ensures a better mixture of the contents.

There are five kilns, each of 30 tons capacity, in a house alongside the limestone and gas-coal stores, as shown, with their cone-shaped chimneys in the perspective view, Fig. 5.

In line with this building is seen the electric-furnace house, with twelve electric furnaces, each of 1400 kw capacity, producing from 7 to 8 tons of carbide per day of 24 hours. The furnaces are teemed into special ladles, which are taken up by an electric high-level telpher railway, and their contents deposited as a flat, square block on the cooling house benches, where it is broken up into lumps, and as such subsequently taken by band-conveyors, to the extensive plant for breaking it up into cubes of the desired size, or direct to the cyanamide or nitrolime works.

From first to last, the handling of the material is almost entirely mechanical. In the same way labor-minimizing machinery has been introduced for the manufacture of the drums and the covering wooden cases in which the carbide is exported.

The nitrolime works form a continuation of the carbide works, and are seen on the left of Fig. 5, the largest building being the silos. The Linde house, shown on the plan, Fig. 4, contains the refrigerating machinery, by means of which nitrogen and oxygen are extracted from the air by liquefaction. The Linde plant is run by a 200-hp motor and produces 375 cu. m (13,244 cu. ft.) of nitrogen per hour.

Calcium carbide, pulverized in the crushing house shown in the plan, is fed through hoppers and chutes into the portable furnaces, which are then placed on the furnace benches and there have connection with the nitrogen gas mains, and with the electric conductors for the electrodes. There are 200 furnaces in the furnace house, operated at 75 volts, to maintain a temperature of 800 deg. to 1000 deg. C. (1475 deg. to 1830 deg. Fahr.).

The cyanamide or nitrolime is crushed and taken by belt-conveyors and elevators to the silos. There is a warehouse for nitrolime as well as carbide.

The export quay is built of stonework, and has a length of 100 m (328 ft. 1 in.) and a width of 12 m (39 ft. 4 in.). There is an electric traveling crane, designed to load 50 tons of carbide per hour, the lifting capacity being 1 ton.

Aluminium Electrolytic Condensers of High Capacity.

For many purposes, for improving the power factor of alternating-current networks or for starting single-phase synchronous motors, etc.—practical condensers of high capacity would be very desirable. The cost of such condensers, made with solid dielectries, like mica or paper, would, however, be prohibitive.

On the other hand, it is easy to make aluminium electrolytic condensers of high capacity. They may become even of practical value, if a pure capacity without any energy losses is not required. The weak point of aluminium electrolytic condensers, as compared with mica condensers, is that they have considerable energy losses.

The aluminium electrolytic condenser has been discussed in two American Electrochemical papers of Mr. C. I. Zimmerman (our Vol. II, p. 182, and Vol. III, p. 172). It has recently been the subject of an investigation of Dr. Günther Schulze, carried out in the German Reichsanstalt and published in *Elektrotechnik und Maschinenbau* (Vienna), March 14.

The "critical voltage"—that is, the maximum voltage which an aluminium anode will stand without letting any appreciable amount of current pass—is given for aluminium in different electrolytes in the following table, for 0.1 equivalent normal solutions after 24 hours of formation:

TABLE 1.

Na_2SO_4,	40 volts	Na_2SiO_3,	445 volts
$KMnO_4$,	112 "	NH_4HPO_4,	460 "
$(NH_4)_2CrO_4$	122 "	Ammonium citrate,	470 "
KCN,	295 "	$Na_2B_4O_7$	480 "
NH_4HCO_3,	425 "		

The valve effect of the aluminium anode is due to an exceedingly thin oxide or hydroxide film on the aluminium plate, covered by a thin gas layer, the resistance of which per square centimeter amounts to millions of ohms. Such an anode may be considered as a condenser. In comparing such an anode to an ordinary solid condenser, the gas layer corresponds to the dielectrics, and the aluminium anode and the electrolyte correspond to the two plates of the condenser.

The capacity of this condenser depends only on the voltage

of formation and the material of the anode and is independent of the nature of the electrolyte.

Fig. 1 gives the capacity as function of the formation voltage for aluminium, tantalum and magnesium. The abscissas are the voltage of formation, the ordinates, the capacity per square centimeter surface. The second set of curves in this figure shows the increase of calculated thickness of the gas layer with increasing formation voltage.

By passing from lower to higher voltages, the thickness of the gas layer increases and assumes its new value within a few minutes. By passing back from the higher to the lower voltage, however, it takes months until the thickness of the gas layer is reduced again to its former value.

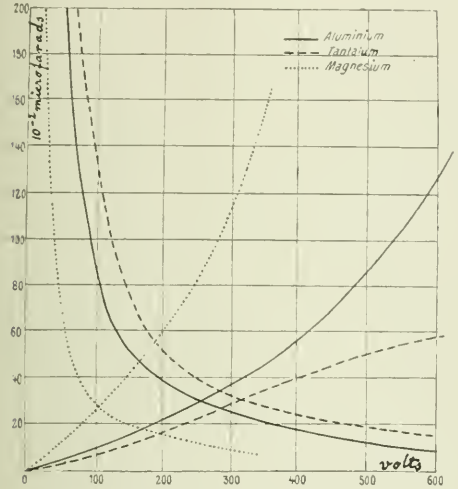

FIG. 1.—EFFECT OF FORMATION VOLTAGE.

For short experiments the thickness of the gas layer may be considered as constant, as long as the voltage remains below the voltage at which the anode was formed. In this case the electrolytic condenser behaves like a condenser with unchangeable dielectrics.

If, however, the formation voltage is increased, the capacity is inversely proportional to the formation voltage.

The aluminium electrode shows the valve effect only as long as it is anode, while it permits the current to pass freely when it is cathode. An electrolytic condenser must therefore be made of two aluminium (or magnesium, etc.) plates. For any direction of the current, only the one electrode which is anode, produces the condenser effect. An electrolytic condenser has not necessarily the same capacity in opposite directions of the current. To assure this, both electrodes must have an equal surface in the electrolyte and must be formed at the same voltage.

In the practical manufacture of electrolytic condensers attention is to be paid to the fact that the oxide film and the gas layer adhering to it cover only those parts of the aluminium electrode which are in the electrolyte. From those points of the aluminium surface which are just above the electrolyte the electric current tries to jump over from the aluminium plate into the electrolyte, causing considerable heat and corrosion of the aluminium. It is, therefore, important to make this aluminium boundary line between electrolyte and air as short as possible and to insulate it very carefully.

The aluminium condenser used in Schulze's experiments contained 10 aluminium plates of the dimensions of 9.7 cm x 16.5 cm x 0.1 cm. Each plate was cut near the top, as indicated at *a* and *b* in the left-hand top diagram of Fig. 2. The two strips, thus formed at the top on both sides, were then bent upward (see left-hand bottom diagram of Fig. 2), and the plate was then reversed (i.e., the two end strips downwards) and suspended in an $NH_4HB_2O_4$ solution, so that the two strips were in solution, and the plate just touched the electrolyte.

Formation was then carried out at a maximum voltage of 500 volts. In this way a resistant oxide film was produced, as indicated by the dark-lined portion in the left-hand bottom diagram of Fig. 2. From the upper ends of the two strips the oxide film was again removed in order to make good connection with the copper wires leading to the external circuit. A close-fitting piece of rubber pipe was then placed over aluminium and copper, around this a glass tube with an insulating compound, and around this again a piece of rubber pipe, as shown in the right-hand diagram of Fig. 2.

This method of insulation prevented, with few exceptions, any corrosion of the aluminium plates at the boundary line between electrolyte and air during the experiments, which lasted several months. The total length of the boundary line was only 6.4 cm for a total plate surface of 3250 sq. cm.

The residual current ("reststrom") was very small. For instance, after the condenser had been connected for several weeks to a direct current = voltage of 110 volts, the residual current became constant = 0.0005 amp. If we assume that the current density over the whole surface was uniform, the current density was 0.00000015 amp per square centimeter, or the resistance of the gas layer per square centimeter surface was 733 megohms.

But, as a matter of fact, the residual current, after connection to constant voltage for a long time, was always found to be smaller the shorter the length of the boundary line for the same electrode surface. This indicated that the residual current passed almost completely through the boundary line, while the residual current through the gas layer over the rest of the surface tended to become zero.

The different aluminium plates of the condenser were fitted with the glass tubes in a fiber plate which formed the cover of the cell. Either a glass vessel was used, when it was desired to render the condition of the electrodes visible, or a painted brass container, when it was desired to cool the electrolyte effectively.

In order to facilitate the formation of the aluminium plates with direct current, a platinum electrode was inserted in the electrolyte and served as cathode, while the aluminium plates were all connected in parallel and served as anodes.

When used with alternating current the odd numbers of the plates formed one pole and the even numbers the other pole. The mean distance between any two plates was 0.5 cm.

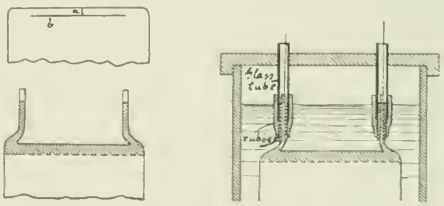

FIG. 2.—CONSTRUCTION OF CONDENSER.

A saturated solution of $NH_4HB_2O_4$ was used throughout as electrolyte, being apparently the most suitable one.

For alternating-current tests of aluminium electrolytic condensers it is advisable to form the aluminium plates with direct current at that voltage which corresponds to the maximum value of the alternating-current voltage to be applied during the tests.

For the final tests an alternator was used giving approximately a sinusoidal voltage curve. The condenser was connected for several days to a direct-current pressure of 40 volts

and was then connected to the circuit of the alternator, the maximum voltage of which was the formation voltage of the condenser. The results are given in Table II.

TABLE II.

Duration of tests in minutes.	Curr't voltage loss of condensers. Amp.	Volts.	Watts.	Temperature of electrolyte.	Power factor.	Capacity in microfarads	
0	1.27	27.6	1.95	19.2° C.	0.056	146.7	After formation at 80 volts for four days. Residual current 0.0045 amp. Maximum voltage of alternating current of test = 84 volts.
1	1.27	27.6	1.90	19.3	0.054	146.7	
2	1.26	27.4	2.25	19.7	0.065	146.3	
[illegible]	1.36	59.2	4.5	17.7	0.056	73.1	After formation at 40 volts for several days. Residual current 0.003 amp. Maximum voltage of alternating current of test = 39 volts.
[illegible]	1.35	59.2	4.0	17.8	0.050	72.6	
60	1.35	59.2	4.0	18.0	0.050	72.6	
0	1.34	113	0.8	19.3	0.044	37.7	After formation at 160 volts for six days. Residual current 0.0037 amp. Maximum voltage of alternating current of test = 159 volts.
3	1.36	112.6	11.3	19.3	0.074	38.4	
10	1.46	112.1	16.5	19.7	0.101	41.3	
30	1.60	112.5	20.5	21.0	0.114	45.0	
60	1.72	113.4	23.0	22.8	0.118	48.2	
0	1.32	93.7	1.0	20.0	0.081	44.9	During one week the d.c. voltage was held constant at 110 volts, the circuit being repeatedly broken and the poles reversed. Residual current 0.0025 amp. Maximum voltage of alternating current test 132 volts.
10	1.33	93.7	10.6	20.2	0.085	45.2	
60	1.43	93.8	12.4	21.9	0.092	48.5	

Table II shows that the energy losses are low with an alternating voltage of 27 or 59 volts and hardly increase when the condenser is connected to the circuit continually for an hour or two. But an increase of the losses in time is evident at 93 volts and assumes quite a considerable value at 130 volts.

When the condenser had been formed with direct current at 400 volts and was then employed at an alternating voltage of 250 volts, the power factor increased to 0.3.

If other electrolytes than borates are used, the losses are probably even higher, since with borates the constancy of the gas layer is a maximum and the residual current is a minimum.

In the case of condensers to be used without interruption for a longer period, it is, therefore, advisable to make the voltage for one condenser not higher than 90 volts, and to connect several condensers in series for higher voltage.

The capacity given in the seventh column was calculated by multiplying the current with the sine of the angle of phase difference and dividing by voltage $\times 2n\pi$. This calculation is permissible only if the currents and voltages have sine waves. By special experiments this was found to be true.

Some results of Table II are quite interesting. The capacity current was constant = appr. 1.3 amp, independent of the voltage applied, as long as the maximum value of the alternating-current voltage was approximately the voltage of formation.

After the third series of experiments (carried out at 113 volts effective) the condenser was connected to a direct-current voltage of 110 volts for about a week, the circuit being repeatedly broken and the poles reversed. It was then connected to an alternating-current circuit of 80 volts effective (maximum value, 117 volts). The capacity current was then found to be only 1.13 amp (instead of 1.32); this indicated that the thickness of the effective gas layer had not been reduced to the value corresponding to 110 volts, but much less, namely, to a value corresponding to 132 volts (maximum value). When tested at this voltage the current was again 1.32 amp, as shown in Table II.

A second important conclusion from Table II is that the product of capacity and formation voltage is almost constant. From the four series of tests of Table II we find:

Volts.	Microfarads.	Product.
40	147.7	5870
80	73.1	5850
132	44.9	5930
160	37.7	6030
	Mean,	5920

The slight increase of the product with the voltage is due to the fact that the capacity of the upper rim of the plates (formed at 500 volts) manifests itself more strongly the higher the formation voltage of the plates.

On the basis of the mean value 5920 for the product, the capacity for 100 volts formation pressure would be 59.2 microfarads.

According to the curve in Fig. 1 the capacity of 1 sq. cm aluminium surface at 100 volts is 0.0858 microfarads. The total surface of the condenser was 3250 sq. cm, of which, however, only 2800 can be considered as effective (subtracting the strips at the top and the upper rim of the plates).

Each of the two equal electrodes has, therefore, at 100 volts a capacity of $1400 \times 0.0858 = 120$ microfarads.

The measurements, however, as stated above, give only 59.2 microfarads, that is, just one-half.

This is, of course exactly right, as has already been pointed out by Zimmerman. The evident reason is that at any moment only the one plate which is anode is effective as condenser while the other plate permits the current to pass.

This fact must be taken carefully into account in designing a condenser of desired capacity. The useful capacity corresponds to only one-fourth of the total aluminium surface in the electrolyte, as for either direction of the current only one-half is to be taken into account and only one-half of this can be utilized.

Finally, Schulze mentions a test of the condenser with an alternating current of higher frequency and its behavior when used for a longer period.

The results of the tests at higher frequencies were as follows:

Frequency.	Voltage.	Capacity current in amperes.
803	102.8	25.6
815	82.8	21.8
823	73.6	19.4
836	59.2	15.0

When the condenser was connected to the circuit for more than a week and the current and voltage were gradually raised from 1.1 amp and 66 volts to 2 amp and 120 volts, while the temperature of the electrolyte increased to 45° C., the condenser stood this test without a visible change.

Notes on Electrochemistry and Metallurgy in Great Britain.

(*From our London Correspondent.*)

Faraday Society.

At the meeting of March 2 papers were read by Dr. V. H. Veley and by Drs. Veley and Cain on "The Rate of Evolution of Gases from Homogeneous Liquids."

The conditions of the evolution of gases from liquids by processes of chemical change were studied, with especial reference to the degree of supersaturation, which appears to have been greatly over-estimated.

The amounts of gases so retained were calculated by comparing the volumes which were actually evolved and those which would have been obtained if there had been no retention. From the solubilities of the several gases in water, the only data available, the supersaturation values were determined. It appears that this value does not exceed 8 to 12, according to the nature of the gas and conditions of experiment.

The lag factors due to certain opposing side reactions are also discussed for a few cases, and their effects separated from the concomitant initial delay due to gas retention.

The papers elicited quite an extended discussion. Mr. F. E. Weston said he had given considerable attention to the subject since 1898, but anomalous results and lack of opportunity to fully investigate had not permitted his experiments to be fulfilled. He described briefly his methods of experimenting, and stated that he found it possible to keep the temperature con-

stant for a whole working day to one-tenth of a degree centigrade when the bath had been adjusted. In many experiments when the final reading had been taken, the liquid in the bath was stirred by the thermometer, and the further evolution of nitrogen was observed; but the volume of nitrogen so liberated would not account for the decrease noted in the velocity-constant. Mr. Weston furnished observations of two typical sets of experiments; the volumes of gas evolved were the means of three sets of observations for each temperature, the individual observations differing by amounts varying from 0 to 2 per cent from the mean.

Dr. J. C. Cain considered that the omission of a thermometer in the reacting liquid in Mr. Lamplough's experiment threw great doubt on all the results recorded by him. He questioned the value of a blank experiment where temperature was concerned, especially in measuring velocity-constants, which varied enormously with temperature. He also pointed out that the decomposition of a diazo salt was exothermic, and he himself had invariably observed that the heat evolved in experiments performed at higher temperatures was great enough to raise the temperature of the solution by 2 deg. to 3 deg. This fact, in conjunction with the record of Mr. Lamplough's method of heating the diazo solution "one or two degrees higher" than the temperature of the bath might fully account for the higher figures of the velocity constants obtained. Taking his own value in the case of diazo-benzene chloride at 50 deg. to be correct, then Mr. Lamplough's value would correspond with 53.5 deg. Mr. Lamplough had questioned the contention of Cain and Nicoll that their experiments confirmed earlier observations on the unimolecular nature of the reaction, but he doubted whether numbers which agreed, but were to be found for any other unimolecular reaction. A comparison of the results of the worst experiments of Cain and Nicoll and of Lamplough indicated that the differences were of the same order in each case. It was noteworthy that in Mr. Lamplough's experiment at 36 deg. the facts recorded were practically all alike, notwithstanding inherent errors in observation.

Mr. Lamplough dealt with the experimental justification of his method, and briefly stated how he had ascertained the values for the degree of supersaturation obtained in his experiments on the decomposition of diazo-benzene chloride. He directed particular attention to the fact that in the experiment with agitation of the solution there was no evidence of any departure from unimolecular law in the experiment: without stirring the action simulated a unimolecular action for a limited range, but with a much lower velocity-constant. With regard to the decomposition of formic acid, the speaker gave an extract from Dr. Veley's paper (*Phil. Trans.*, 1888, p. 264), vividly describing the effervescent action produced by introducing silica into a mixture of formic acid and sulphuric acid which had been allowed to react for 25 minutes without agitation, and further experiments with formic and sulphuric acids described in the same paper. Mr. Lamplough considered that the calculations in pages 4 to 6 were open to serious objection, which opinion he proceeded to sustain; and in conclusion stated that he did not consider his apparatus favorable to the attainment of high degrees of supersaturation, as he believed that if more favorable conditions were adopted much higher values than 100 times the normal saturation amount might be obtained for the degree of supersaturation.

Dr. Santer said that the fact that there is often considerable supersaturation when gases are generated in a liquid had been known for many years; and recently it had been widely recognized that where rates of reaction were estimated by measuring the rate of evolution of a gas, the results could only be entirely depended on when there was continuous agitation of the solutions. It followed that the facts were perfectly well known by recent publications on the subject, concerning which there has been so much discussion. As to the want of agreement in opinion between Dr. Cain and Mr. Lamplough he desired to recall the fact which had so far not been referred to that evening, namely, that the vessels in which Dr. Cain's solutions were treated contained a large quantity of glass beads; and the increase of surface so obtained must have considerably reduced the tendency to supersaturation. The comparatively simple formula put forward by Dr. Veley could not, in his opinion, represent the state of affairs in a quiescent (and therefore supersaturated) solution with any great degree of accuracy.

With reference to Dr. Cain's and Dr. Veley's paper, Dr. E. Feilmann said that an important question arising from that very interesting paper was that of the state in which the gases existed in a supersaturated liquid. Judging from recent views of the nature of colloidal solutions, it seemed possible that the gas was present in particles of almost molecular dimensions, which slowly aggregated to greater masses until their tendency to rise overcame the viscosity of the liquid. Probably such minute particles of gas would be electrically charged, and the decomposition of the solution of ammonium nitrite under the influence of an electric field in a gas voltameter would be of considerable interest if it were noted whether the liberation of nitrogen occurred largely or entirely at one pole in preference to the other. The observation whether an increase in the viscosity of the liquid caused by the addition of a protective colloid, such as gelatine, increased the amount of supersaturation also deserved attention. He was aware that Findlay had already published results of experiments on the augmented solubility of gases in colloidal solution; but the conditions in such a case would not be identical. Why the gas evolved from a homogeneous liquid should tend to form at one point more than at another was not easy to understand; and it appeared that the conditions closely resembeled those existing in an ordinary superheated liquid, and consequently it might be expected that a very unstable system would be obtained under suitable conditions.

The National Physical Laboratory.

Absence from London prevented my utilizing the invitation to the annual inspection at the National Physical Laboratory at Teddington. Instead, therefore, of commenting on new apparatus and methods of research from an actual visit to the place, I am compelled to glean from the annual report of last year's work notes of metallurgical interest for these columns.

Electric Laboratory Furnaces.—In the thermometric division much of the time of the staff has been given to the organization and equipment of two new laboratories. Reference should be made to the new spiral tube carbon furnace designed by Mr. W. A. Price and Dr. Harker, and to the remarkable increase in efficiency reached in the ordinary type of platinum resistance furnace by proper attention to the design. In the old furnace of the original platinum resistance design, having an internal capacity of 100 cc, the expenditure of 3300 watts was needed to reach a temperature of 1350° C. The new furnace has a capacity of 150 cc, and the same temperature can be reached by the expenditure of 1400 watts.

In connection with the tests on new resistance alloys, and also on various samples of an alloy used for making resistances for use in the laboratory, it has been found that the temperature coefficient varies considerably with different samples of the same alloy, and also with different sizes of wires of the same batch of material. Some preliminary tests have been made, and it is proposed, in conjunction with Mr. Rosenhain, to investigate the discrepancies fully.

In connection with the new thermometer testing baths for the thermometry department, a series of experiments was carried out at the suggestion of Mr. W. A. Price, with a view to devising a satisfactory form of electric heating unit. The form finally adopted was to wind a thin strip of "Eureka" resistance material on a thin sheet of mica, the electrodes of copper strip being then threaded into the mica and hard soldered to the Eureka strip. A thin sheet of mica is laid on each side and sewn around the edges, and the whole is slipped into a thin copper envelop, which is let into and soldered to the lower side

of the latter. This envelop being a nice fit round the mica, the unit can be easily removed for renewal or repair, without moving or emptying the bath. Some of the units have been in use for several months for heating baths up to 100° C. without a single case of breakdown. Each unit is made in two sections, each of which will take 4 amperes at 100 volts, i.e., a total of 800 watts per unit, and by means of suitable switches they can be put in series, or singly, or in parallel, as occasion demands.

In the thermometry department, Mr. W. A. Price and Dr. Harker have perfected the details of a type of furnace in which most of the defects of the carbon-tube furnace are absent. One great advantage of the new type is that its resistance is not limited solely by dimensional considerations, but may be chosen to suit the experiment and the supply of current available. In the new form of furnace the carbon tube is retained as a lining only, the heat being supplied by the current in a graphite spiral, surrounding, but carefully insulated from the central tube.

Three sizes of furnace have now been made and run successfully. In the last of these the heater was machined from a tube of graphite of 3 in. external and 2 in. internal diameter, the ventral portion being cut on a lathe to form a spiral of 16½ turns, the thickness of the turned portion being ⅜ of an inch, the pitch 2·3 in. and the space between the turns 3/16 in. Through the center of this spiral passes a long tube of arc lamp carbon of ¾ in. internal diameter. This tube is insulated from the spiral and serves to carry the bodies to be heated.

The heating current is led in and out of the spiral by means of two flattened copper tubes, ¾ in. diameter, resting as saddles on the solid ends, good contact between the coper and carbon being insured by a layer of tinfoil, a weight of 10 lb. being hung on a crossbar, joining the two limits of each saddle below. The current is supplied to these bars by stout cables of dynamo flexible. Through the copper tubes a water circulation is maintained, which completely prevents any serious heating.

The whole furnace is mounted in a cubical cell built of firebrick of about 2 ft. wide and covered externally with a cement dressing. It is supported on a slab of York stone by walls 3 ft. high, over a trench in the floor of the furnace room. To prevent oxidation of the heating spiral, this is packed in a thick layer of lamp black, made from vegetable material and containing very little inorganic matter.

The lagging of the furnace consists of bricks and slabs of magnesia boiler covering, these being arranged so as to stop any convection currents inside the furnace as completely as possible. This furnace attains a temperature of 2000° C., with 150 amperes at 40 volts, while the average life of the type is much greater than that of the older pattern. It has been employed for the determination of a number of high melting points for the standardization at high temperatures of optical pyrometers. It will also be used for baking tubes, thermometer reservoirs and other articles made of rare earths.

Chemical Elements and Electronic Theory.

In the course of his presidential address to the Chemical Society, Sir William Ramsay said that his subject was the hypothesis that the genuine difference between elements was due to their gain or loss of electrons. The question was whether, to take a concrete example, an atom of sodium by losing or gaining electrons remained an atom of sodium, or whether the loss or gain of electrons did not cause it to change into some other element or elements.

Having stated some theoretical arguments in favor of the possibility of transformation, he went on to describe some experiments bearing on the question. He first mentioned the transformation of radium emanation into helium, which had been amply established. He next referred to his experiments on the action of emanation on solution of copper sulphate and nitrate. Four experiments were made, and with each exactly similar duplicate experiments were tried in which no emanation was employed. A larger residue was obtained in each case from the emanation solutions than from the duplicates, and, while the residues from the emanation solutions showed a faint trace of lithium, those from the duplicates failed to give spectroscopic evidence of the presence of that element.

The fact of the experiments having been carried out in duplicate rendered inapplicable the criticism of Prof. Hartley that accidental contamination with lithium was probable. As regards the alleged repetition of the experiments by Mme. Curie and Mlle. Gleditsch, who, using platinum vessels, obtained no greater residue and no trace of lithium, there were two possible replies—either the conditions were varied, or conceivably a trace of lithium from the glass vessel employed (which, however, had been tested for lithium with negative result) was dissolved in presence of emanation and copper, but escaped solution in absence of copper or of emanation.

A research on the action of emanation on solution of silver nitrate contained in a silica bulb yielded negative results, but he had stumbled across a case of apparent transformation while working in a totally different direction. On Dec. 20, 1905, 270 grams of purified thorium nitrate were dissolved in about 300 cc of water, and the flask in which the solution was contained was repeatedly evacuated by a mercury pump until no gas could be pumped off. The stopcock attached to it was then closed, arrangements being made so that if any leakage occurred it would be detected. After the flask had stood for 168 days the gas in it (5.750 cc) was pumped out and examined for helium, with doubtful results. The flask was again closed, and on Aug. 3, 1907, after 173 days, the gas in it was again examined. Again the presence of helium was questionable, but 1.08 cc of carbon dioxide was found. At the next examination of March 30, 1908, there was distinct evidence of a helium spectrum, and the gas contained 1.209 cc of carbon dioxide.

It was then thought possible that the carbon dioxide had been produced from the grease of the stopcock, and therefore a little mercury was introduced into the capillary tube leading to the stopcock, so that the latter was protected from contact with the thorium solution. After 310 days the gas was again withdrawn. Instead of 3 cc or 4 cc, no less than 180 cc were collected; it was almost pure nitrogen, but in all 0.622 cc of carbon dioxide was separated from it.

These experiments, Sir Wm. Ramsay said, rendered it at least probable that thorium engendered carbon dioxide, or, in other words, that carbon was one of its degradation products. Experiments further indicated that the action of radium emanation on thorium nitrate solutions was also attended with the formation of carbon dioxide, and the same was the case with an acid solution of zirconium nitrate. An experiment with lead chlorate proved blank, but with bismuth perchlorate the formation of carbon dioxide appeared certain.

In conclusion, Sir Wm. Ramsay, after mentioning that every precaution which could be thought of was taken to exclude foreign gas, said that, while these were the facts, no one was better aware than he how insufficient was the proof, and that many other experiments must be made before it could be confidently asserted that certain elements when exposed to "concentrated energy" underwent degradation into carbon.

London, March, 1909.

SYNOPSIS OF PERIODICAL LITERATURE.

Industrial Electrochemistry.

Electric Steel in England.—The progress which the electric steel furnace has made in England is summed up by F. M. Perkin in the London *Electrician* of March 26, as follows: Messrs. Edgar Allen & Company, of Sheffield, are building a 3000-kg furnace of the Héroult type. There is a 60-kw experimental Roechling-Rodenhauser furnace in operation at Battersea. The National Physical Laboratory have also a small experimental furnace, which was presented to them by the Roechling-Rodenhauser Company. It is also understood that

the Anderson electric steel furnace will shortly be in operation in Sheffield. This furnace is of the smothered-arc type and is supported on trunnions in order to facilitate tilting and pouring. The electrodes pass through the furnace cover, and may either be connected in parallel or series. Immediately below the electrodes, and beneath the base of the furnace, is a powerful electromagnet, which is used to control the arc. This is the chief novelty of the furnace and is stated to very much increase its efficiency. Vickers, Sons & Maxim have an induction furnace, but whether they are doing much or little with it is not made public.

Ferrosilicon.—In the London *Electrician* of March 26, F. M. Perkins remarks that ferrosilicon is a splendid, acid-resisting material. It has been most successfully employed for making condenser works for nitric-acid plants and for the evaporation of acids. Ferrosilicon also forms very useful electrodes for the electrolysis of fused salts. (See the article by Jouve in our Vol. VI, p. 321.)

Calcium.—In an article by F. M. Perkin, in the London *Electrician* of March 26, the manufacture of metallic calcium by the electrolysis of the chloride is said to be slowly progressing, but unless more outlets are found for the use of this metal it will never be a large industry. It has been tried in place of aluminium for "thermit" reactions, but the low price of aluminium, and also of silicon, which has been found useful for these reactions, will prevent metallic calcium being employed, even if it were as satisfactory as these. Probably the chief use of calcium is as hydride, which it has been suggested might be employed as a ballast for balloons and then for regenerating hydrogen gas for long aerial voyages. After being acted upon by water and the hydrogen gas having been given up, the lime remaining could be thrown away, thus also lightening the car.

Calcium Carbide in Japan.—As noted in London *Electrical Engineering* of March 18 Japan is now about to supply all the calcium carbide required for her home consumption, which is estimated at 90,000 kg per month. A new power station has been erected by a company, with a capital of $300,000, on the Falls of the Soki, near Kagoshima, where water power capable of generating 10,000 hp is available. There are two qualities of carbine manufactured in Japan, the better grade costing about 3.7 cents per pound, and the inferior grade, which is useless for lighting purposes, 1.5 cents per pound. It is even contemplated enlarging the works in order to manufacture calcium carbide for export.

Copper from Ores.—In an article by F. M. Perkin in the London *Electrician* of March 26, we find the following note on the production and refining of copper directly from its ores. This does not seem to be much nearer attainment than heretofore, although attempts are continually being made in this direction. One of the chief difficulties is the large amount of gangue which has to be leached out, and the consequent loss of electrolyte or leaching material. It appears, however, that an attempt is being made in this direction in the English Lake district. At one time considerable profits were made by mining copper at Coniston, but it is a long time since operations were given up. There remain, however, large dump heaps which contain from 1.5 to 2 per cent of copper, and it is proposed to recover this by a process of T. Scott Anderson, of Sheffield. The company holding the patents and who hope to carry out the operation is the Annandale Copper Mines & Smelters (Ltd.). The electrical energy necessary will be obtained from water power, which is stated to be plentiful in the neighborhood.

Another process of O. Froelich (described more fully in *Elektrochemische Zeitschrift*, November, 1908), is as follows: In all previous processes the ore is first roasted in the air. In this process the ore is heated out of contact with air from 200° C. to 300° C.; this converts the ore into cuprous and ferrous sulphide with liberation of sulphur, thus:

$$2\,FeCuS_2 = Cu_2S + 2\,FeS + S.$$

The ore is subsequently leached out with ferric chloride, which dissolves the copper as cupric and cuprous sulphide. The copper is then thrown out by addition of iron and can be further purified by casting into anodes and electrolyzing. When the copper is thrown out by the iron the noble metals remain in the leaching solution, from which they are easily recovered.

Acetylene Chlorides and Ethane Chlorides from Electrolytic Chlorine.—In the London *Electrician* of March 26, F. M. Perkin refers to a new outlet for electrolytic chlorine which has been particularly developed in Germany, namely, the formation of acetylene chlorides and ethane chlorides. The starting materials in this case are all electric or electrolytic. Calcium carbide is produced in the electric furnace, which, when acted upon by water, yields acetylene. The acetylene is then caused to combine with electrolytic chlorine, with formation of acetylene chloride, dichloride and so on up to perchlorethane C_2Cl_6. These products come onto the market as solvents for oils and fats, and, being practically non-inflammable, they will probably in time be largely employed in place of the inflammable solvents—benzine, carbon-disulphide, etc., at present used.

Electrotyping and Plating.—Recent progress in these arts in England is summed up by F. M. Perkin in an article in the London *Electrician*, March 26, as follows: In place of the wax or gutta molds employed for reproducing electros, recently celluloid sheets have been used. Sheets of celluloid are warmed so that they become plastic and then placed over the positive a reproduction of which is required. They are then hydraulically pressed as usual, the interior surface blackleaded, coated with copper in the usual way by rinsing in copper sulphate and sprinkling with iron filings. After this they are washed and placed in the depositing bath. The process has not come into at all general use. The chief advantage claimed is that, after removing the deposit, the mould can be stored indefinitely and employed again and again, because the removal of the deposit does not appear to injure it. "In reference to the electroplating industry there is not very much new to report. There have been, as usual, a great number of formulas published and patented. In a good many of these the addition of organic substances to the electrolyte has been recommended. Thus, for example, extract of liquorice root and other similar extracts, sugar and yeast, to give a fermentation bath, and so on. Probably platers would be well advised to leave the majority of these rather messy concoctions severely alone."

Zinc Plating.—In an article by F. M. Perkin, in the London *Electrician* March 26, the remark is made that electrolytic zincing only makes very slow headway, probably partly owing to the appearance of the deposit—matt gray. By burnishing the electrolytically deposited zinc will take on a beautiful and brilliant polish, but this means a second operation, and is not readily applicable to irregularly shaped articles. Dr. Carl Richter finds that by keeping the bath slightly acid (1 38 to 1/20 normal), brilliant deposits which show a leafy, crystalline surface can be obtained. He keeps his bath at atmospheric temperature, and employs a current density of 740 amp per square foot, with a potential drop of 0.75 to 0.85 volt

Ozone for Purification of Water.—In the London *Electrician* of March 26 F. M. Perkin states that the purification of domestic water by means of ozone is gaining ground in Europe. The Lahmeyer Electric Company have placed a very neat apparatus upon the market which automatically purifies the water as it is drawn off from the supply tap The turning on of the tap sets the ozonizer in operation, and the flow of the water draws the ozone through it. The water thus leaves the pipe in a sterilized condition. There has been an interesting discussion in the *Times*, initiated by Sir Oliver Lodge, as to whether the breathing of limited quantities of ozone is injurious. "Some persons consider that catarrh is caused by the inhalation of the gas mixed with air It would appear to be rather a question of personal idiosyncrasy Personally I have found the opposite effects, colds having been cured by working in an atmosphere containing ozone" Although the amount of energy

used in the production of ozone is comparatively small, yet if this method of water purification were to come more into use it might help to fill in the valleys of generating stations. There should be no great difficulty in arranging to work the ozonization during times of light load, and, in order not to inconvenience the users, to store the sterilized water in reservoirs.

Sterilization of Water by Ozone.—According to *Le Genie Civil*, Vol. 54, page 57 (abstracted in *Elek. Zeit.*, March 18) there is a water purification plant in Chartres, in France, for treating 6000 cu. m of water from the River Eure in 24 hours. The water is first filtered through sand and coke and the number of bacteria is thereby lessened to about one-fifth the original value. The balance is killed by means of ozone. The Otto ozone system is used. An alternator provides current at 250 volts and 500 periods. This high frequency is necessary to obtain a good efficiency for the production of ozone. The voltage of the single-phase current is raised to 20,000 and at this pressure the current is supplied to the electrodes of the ozonizer. The purification of 1 cu. m of water requires 2 grams of ozone, corresponding to 50 watt-hours. Recent improvements are expected to increase the efficiency still further.

Theoretical and Experimental.

Electric Laboratory Furnaces.—From the report of the director of the (British) National Physical Laboratory (Lond. *Engineering*, March 26) we note that Dr. J. A. Harker and Mr. W. A. Price have perfected the details of a type of furnace in which most of the defects of the carbon-tube furnace are absent. In the new form of furnace the carbon tube is retained as a lining only, the heat being generated electrically in a graphite spiral, surrounding, but carefully insulated from the central tube. The graphite spiral can expand without causing trouble at the contacts. The spiral is cut on a lathe from a graphite tube of 3 in. and 2 in. external and internal diameter, the turned groove being completed with the aid of a knife. On the ends rest the weighted saddles of flattened copper tubes, forming the water-cooled terminals. The whole furnace is mounted in a cubical cell built of firebrick of about 2 ft. wide, and covered externally with a cement dressing. It is supported on a slab of York stone by walls 3 ft. high, over a trench in the floor of the furnace room. To prevent oxidation of the heating spiral, this is packed in a thick layer of lamp black, made from vegetable material, and containing very little organic matter. The lagging of the furnace consists of slabs and bricks of magnesia boiler-covering these being arranged so as to stop any convection currents inside the furnace as completely as possible. This furnace attains a temperature of 2000 deg. C. with 150 amp at 40 volts. It has been employed for the determination of a number of high melting points for the standardization at high temperatures of optical pyrometers. It is also used for baking rare earths. Properly baked tubes of the rare earths can be heated in the oxy-hydrogen flame and dipped into cold water, being as indifferent to sudden temperature changes as fused quartz.

Electric Heating Unit for Thermometer Tests.—In connection with the new thermometer testing baths for the Thermometry Department of the (British) National Physical Laboratory, a series of experiments were carried out at the suggestion of Mr. W. A. Price, with a view to devising a satisfactory form of electric heating unit. The form finally adopted was to wind a thin strip of "Eureka" resistance on a thin sheet of mica, the electrodes of copper strip being then threaded into the mica, and hard soldered to the Eureka strip. A thin sheet of mica is laid on each side, and sewn round the edges, and the whole is slipped into a thin copper envelop, which is let into and soldered to the lower side of the bath. This envelop being a nice fit round the mica, the unit can be easily removed for renewal or repair without moving or emptying the bath. Some of the units have been in use for several months for heating baths up to 100 deg. C. without a single case of breakdown. Each unit is made in two sections, each of which will take 4 amp at 100 volts; i.e., a total of 800 watts per unit, and by means of suitable switches they can be put in series, or singly, or in parallel as occasion demands. This note is taken from the report of the Director of the (British) National Physical Laboratory for 1908, published in abstract in the Lond. *Electrician* of March 26.

Effect of Electrolytes on Colloids.—The well-known precipitation of colloids by the addition of a trace of an electrolyte to a colloidal solution is the subject of a paper by E. F. Burton in the April issue of the *Philosophical Magazine*. He has studied the action of electrolytes on copper colloidal solutions and sums up his chief results as follows: For a copper colloidal solution, the particles of which are positively charged (i.e., move to the cathode), the influence of added electrolytes on the velocity of the particle has been determined. The electrolytes used were potassium ferricyanide and aluminium sulphate. Evidence has been produced to show that it is the ion bearing a negative charge that is active in reducing the velocity. This power of the negative ion depends on the valency in a way analogous to the valency relations found by Picton and Linder, and by Hardy, for the coagulative power of ions. The discharging power of two negative ions of the same valency is the same. Observations on the coagulation produced in each case shows that the particles coagulate when they lose their charge.

Synthetic Ammonia.—In London *Engineering* of April 9 we find the following note on the synthetic preparation of ammonia which still remains practically an unsolved problem. The two gases nitrogen and hydrogen do not react on one another at ordinary temperatures; at higher temperature the combination is facilitated by the presence of certain catalysers like iron, but the resulting ammonia is not stable at 1000 deg. Cent., the temperature at which Haber and Oordt experimented. (We should mention, however, that a successful electric-arc process is now spoken of.) It has hence been attempted to make use of metallic nitrides and hydrides; but the just-mentioned experimenters did not find the dissociation pressures of the nitrides and hydrides of calcium and manganese suitable, and E. Baur and Voerman do not recommend chromium-nitride for other reasons. On the suggestion of E. Baur, J. Lipski has hence tried, in the Brunswick Technical College, the compounds of the rare earths, with a certain amount of success. The way in which he proceeds does not look simple. But we remember that after years of failures, the preparation of incandescent mantles for lamps became an important industry, and that the rare earths are now obtainable in quantities which their name hardly justifies. Utilization of the rare earths is a very different thing at present from what it was twenty years ago. In preparing the cerium nitride, Lipski started either from the metal cerium, which the Elektrochemische Werke Bitterfeld supplied to him, or more frequently from the dioxide of cerium, which he treated with magnesium metal in an atmosphere of nitrogen. The metal cerium is steel gray, and can be turned, but is inclined to spark; the nitride is a black powder, which evolves ammonia in damp air; the hydride is a reddish or brown substance, which slowly ignites on exposure to air. These compounds were known, but Lipski has studied their dissociation pressures and reactions. He finds that at 200 deg. or 300 deg. Centigrade two reactions yield ammonia; hydrogen and cerium nitride give cerium hydride and ammonia; and nitrogen and cerium hydride yield cerium nitride and ammonia, so that the cerium serves in both cases as carrier to effect the combination of nitrogen and hydrogen; a third possible reaction, the re-liberation of nitrogen from cerium and hydrogen, does not take place to any noteworthy degree. Very small quantities of moisture and of oxygen interfere with the formation of ammonia, however; even in their absence, the catalysers become exhausted, after a certain time, but they recover. The cerium compounds need not be pure; the technical ceria is just as efficient as raw material. The ammonia percentage in the gas mixture did not exceed 6.4 per cent when using cerium nitride.

and 1.5 per cent when using the hydride. That would technically be sufficient if these yields could be maintained for long periods; the intimacy of the contact is of importance in this respect, of course. The full paper by Lipski may be found in the *Zeitschrift für Electrochemie*, April 1. In parenthesis it may be mentioned that this excellent German electrochemical journal is now being published as a semi-monthly. While chiefly devoted to the science of electrochemistry, it also brings now occasionally notes on industrial and commercial developments in electrochemistry in Europe. Dr. F. Askenasy, of the Institute of Technology of Karlsruhe, is the new editor.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Reduction of Carbon Consumption in Carbide Production.—Mr. Remo Catani, one of the leading electrometallurgists of Italy and especially active in the electrometallurgy of iron and steel, has recently patented a process the object of which is to reduce the carbon consumption in the manufacture of carbides. The chief argument on which the process is based is that the fundamental reaction by which, for instance, calcium carbide is formed, is not $CaO + 3C = CaC_2 + Co$, as generally assumed, but $CaO + 2C = CaC_2 + O$. What really happens in the usual carbide furnace is the occurrence of the following three reactions in succession:

$$2CaO + 4C = 2CaC_2 + O_2$$
$$O_2 + 2C = 2CO$$
$$2CO + O_2 = 2CO_2$$

The first reaction takes place in the hottest part of the electric furnace, the second in a less hot part, and the third in a still less hot part. The object of Catani's process is to suppress the last two reactions. For this purpose he proportions the charge strictly according to the first reaction and coats the carbon in the charge with slaked lime, to prevent the second and third reactions. For calcium carbide manufacture he, therefore, uses a mixture of 24 parts by weight of carbon coated with slaked lime, and 56 parts by weight of calcium oxide—that is, 43 parts of carbon to 100 parts of lime are charged into the furnace. If the furnace is without electrodes or with electrodes of a substance not capable of being attacked by oxygen, the process may be applied directly, whereas when carbon electrodes are used or electrodes apt to be attacked by oxygen, they are coated with slaked lime, or an outlet is formed for the oxygen, keeping the tapping hole of melting furnaces open. The powerful pressure existing in the crucible of the furnace permits the oxygen to escape rapidly as soon as the outlet is opened, which may also be facilitated by suction. The same process may be applied to carborundum manufacture, the fundamental equation being $SiO_2 + C = SiC + O_2$, and to the manufacture of calcium cyanamide from the elements according to the equation $CaO + C + N_2 = CaCN_2 + O$. (918,419, April 13, 1909.)

Electric Furnace.—Mr. C. W. F. Gorrell patents an electric furnace for the fusion and reduction of oxide or sulphide ores. The ore itself forms the resistor and the current is passed through it by means of two electrodes. These electrodes are hollow metallic cylinder, water cooled in the inside, and provided with a carbon tip at the end. A hollow pipe passes through the center of the electrode, and the carbon tip at the end. Through this pipe carbon monoxide is blown into the fused ore mass, if the object is to reduce an oxide, or compressed air if a sulphide ore is treated. (916,548, March 30, 1909.)

Refractory Materials.—The manufacture of artificial emery from alumina, fused in the electric furnace, has made great progress in recent years in the hands of the Norton Co. A recent patent of Mr. A. C. Higgins refers to a method of obtaining a product of exceptional toughness and hardness by sudden cooling. The process is carried out in an electric arc furnace. Fig. 1. It has a movable hearth with a lining of carbon, surrounded by a metallic trough or base-ring 3, which serves to collect the product. The shell or furnace casing 4 may be constructed of boiler plate or sheet iron, and is separable from the hearth, lugs 5 being provided for lifting it. Cooling or chilling of the product is effected by water supplied through perforated pipes 6 surrounding the upper portion of the shell. The perforations in pipe 6 are arranged to direct the water against the shell in such a manner that it flows down the inclined surface in an unconfined stream or film, to be collected by the base-ring 3 and discharged through a suitable waste pipe.

The aluminous material is continuously or intermittently fed to the crucible, and is fused therein by the heat of the arc or arcs, the crucible being in the meantime gradually lowered, as, for instance, by means of a direct plunger hydraulic elevator, the plunger of which is shown at 10. During this operation water is discharged, through the perforated pipes, against the shell or casing 4 in such manner as to cool or chill the molten mass in the crucible and to provide conditions under which the mass solidifies into an exceptionally tough and very hard pig, suitable for use in the manufacture of abrasives.

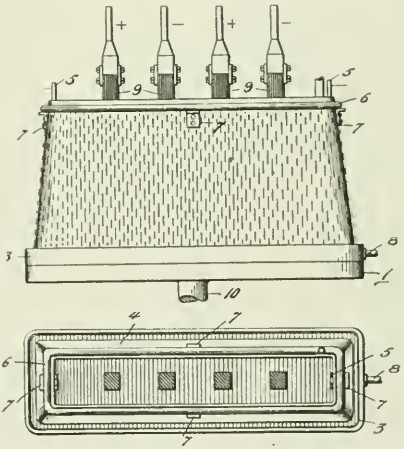

FIG. 1.—REFRACTORY MATERIAL FURNACE.

Since the chilling effect is of particular importance, it is preferable to construct the furnace in the form of a long and narrow chamber. (916,866, March 30, 1909.)

Silicon.—G. O. Seward and F. von Kügelgen recommend an arc furnace, without the use of any fluxes, for the production of silicon. The furnace is illustrated in Fig. 2. *B* is the carbon hearth, *J* the molten bath of reduced silicon. A 15,000-amp 30-volt arc is used with an electrode of 4 square feet cross-section. The charge is a coarsely ground mixture of flint rock and carbon, preferably merely crushing the flint rock to about 1-inch mesh size and grinding the coke so that it shall pass a 10-mesh screen. The mixture is kept piled about 18 inches above the lower end of the electrode, so that the arc is maintained in the midst of the mass of porous mixture. At starting a charge is made up of about 75 parts by weight of flint rock to 25 of coke, so as to introduce a surplus of silica, afterward changing this to 70 parts of flint rock to 30 of coke. There is no excess of carbon, or barely enough to maintain a reducing atmosphere around the incandescent zone of the arc. The temperature maintained under these conditions is above that at which silicon carbide remains staple, so that, even if this material is formed in part, it is immediately decomposed. The silicon is reduced in the form of vapor

and expands into the interstices of the porous mixture, where it combines. These interstices being full of a reducing gas, namely CO, allow the silicon to condense without being oxidized. The reduced silicon percolates down through the porous mass and collects at the bottom of the crucible. It is tapped out with carbon molds from time to time. A reduction zone is thereby maintained at a temperature so high that the sili-

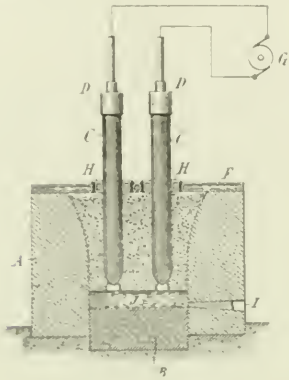

FIG. 2.—SILICON FURNACE.

con carbide cannot form or, if formed in part, is decomposed, and around this zone of reduction a cooler porous condensing zone, the interstices of which are kept filled with a reducing atmosphere which prevents the vapor of silicon from oxidizing before it can condense. (916,793, March 30, 1909.)

Electrolysis of Alkali Chlorides.—A combined mercury cathode and diaphragm cell is patented by J. J. Rink, of Copenhagen, Denmark. The construction is shown in Fig. 3, where *a* is a vessel of bell shape closed at the bottom by a porous diaphragm *b* of asbestos, stone ware, wood, etc. The platinum-iridium net *c*, a short distance above the diaphragm, is the anode. The receptacle *a* is surrounded by another vessel or tank *e* in such a manner that the diaphragm *b* is located at a short distance from a film or layer of mercury *f* which is spread over the bottom of the tank *e*. The space *g*, which if formed between the walls of the vessel *a* and the bottom and walls of the tank *e*, is connected by a horizontal tube *h* at its upper part and by a tube *h'* at its lower part with a concentration-vessel *i* in which the chloride to be treated, for instance, potassium chloride, is placed in solid form. In the tube h^1 is located a circulating-pump h^2 of any approved construction.

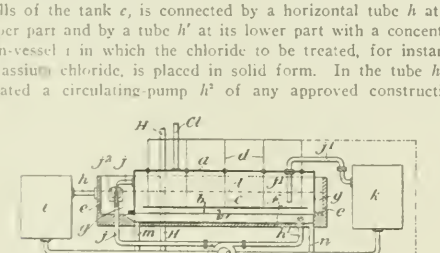

FIG. 3.—CHLORIDE ELECTROLYSIS CELL.

The space in the vessel *a* is in a similar manner connected by tubes j' and j^1 with a second concentration-vessel *k*. The tubes j' and j^1 are each provided with a mercury-seal j^2 for permitting the easy replacement of the same. The spaces in the bell-shaped vessel *a* and the tank *e* are filled up to a level with the line *l* with a chloride solution. The bottom of the tank *e* is covered with the mercury-film and connected by two tubes *m* and *n* respectively with the upper part of a washing-box *O* and a mercury-pump n^1. The tube *m* is tightly fitted into the top part of the box *o* and connected with a perforated horizontal distributing-tube *p* in the upper part of the box *o*. In the washing-box *o* are aranged wire-nettings *s* which are stretched around vertical plates *r* that are located directly under the openings of the distributing tube *p*. Between the wire-nettings *s* are located vertical metal plates *t* which are provided at their upper ends with inclined shedding-strips. The box *o* is filled with water or diluted lye up to a level with the line *u* and connected at its top part with a pipe *H* for the escape of the hydrogen gases. The bell-shaped vessel *a* is connected at its upper end with a conducting pipe C^1 for the escape of the chlorin gas. The solution which becomes gradually diluted by the deposition of alkali metal on the cathode *f*, passes from *g* through *h* in the upper part of the receptacle *i* and permits thereby the ingress (through h^1) of a fresh quantity of a concentrated and pure solution or electrolyte. The solution which is contained in the vessel *a*, and which is gradually diluted by the separation of free chlorine on the anode *c* and by the passage of alkali metal ions through the diaphragm *b*, and which contains chlorine gas and some oxides of chlorine, is gradually forced out by the concentrated solution which is supplied through the tube h^1 and conducted through the pipe *j* into the concentrating receptacle *k*. Simultaneously the amalgam, that is to say, the mercury film *f* is moved in the direction from *n* to *m*. The amalgam which is discharged through the perforations of the pipe *p* drips over the wire nettings *s* and passes through the body of water to lye which fills up the space between the electro-negative plates *r* and *t*, and over the large surface of the latter, so that a quick and complete washing of the alkali metal is obtained. (918,370, April 13.)

Aluminium.—Mr. H. K. Blackmore patents a process which, by the first claim, is characterized as "the process of producing metal, which consists in exposing a substance, containing a metal and oxygen, capable of reacting with a carbide to yield metal, to electrolysis, while employing an anode containing calcium carbide." In the operation of the process he places in the receptacle a quantity of aluminium oxide and aluminium flouride and fuses the same by passing an electric current between the carbon lining of the cast-iron receptacle and the calcium carbide electrode, having first started an electric arc between the same by placing them in contact and gradually separating them. He then feeds the aluminium oxide and aluminium fluoride in at intervals, as it fuses, and continues to add the mixture until the interior of the apparatus has been sufficiently filled; he then adds to the molten content a small quantity of calcium chloride to assist the fluidity of the mixture. "A reducing action is set up between the carbide contained in the electrode, such as calcium carbide, and the electro-negative constituents, fluorine and oxide supplied thereto, whereby they are removed, the fluorine combining with the calcium of the calcium carbide and the carbon liberated with the oxygen thereof, at the same time separating the metallic aluminium which accumulates in the bottom of the apparatus and is withdrawn from time to time through a tap-hole." The carbon oxide evolved from the anode escapes as gas. By supplying new anodes and fresh aluminium oxide and fluoride, from time to time, withdrawing the metal reduced and the accumulating fluorides, the process may be carried on continuously. (918,269, April 13, 1909.)

Plating Iron with Tin.—Hydrofluoric acid, first employed by A. G. Betts for lead refining and later recommended by E. F. Kern for various plating baths, appears to increase in favor with electroplaters. H. L. Hollis recommends an electrolyte of this kind for plating iron with tin. The electrolyte is prepared as follows: Seven parts by volume of hydrofluosilicic acid are added to 93 parts water and this solution is electrolyzed with an anode of tin and a cathode of iron. Tin is first dissolved at a higher rate from the anode than deposited

upon the cathode, but the rate of solution and the rate of deposition become gradually more equal; when the rates are the same, the solution is ready to be used as an electrolyte for tin plating. A small amount of gelatine or glue, added to the electrolyte, increases the density of the deposit. The same method may be used for zinc plating. (916,155, March 23, 1909.)

Nickel Electrode.—Mr. E. W. Jungner proposes a new method of making nickel electrodes for the nickel-iron accumulator. The nickel plate is suspended in a steel vessel filled with slaked lime which is kneaded to a stiff dough consisting of 100 parts of lime and 72 parts of a solution of caustic potash (6 grams of caustic per liter of water) to which are added a few cubic centimeters of ammonia of 0.85 specific gravity. A current of 5 amp per square centimeter is passed from the nickel as anode to the iron vessel as cathode for an hour. When the plate is taken out and the lime is removed, the plate is coated with an adhering layer of nickel hydrate, principally $NiO\,H_2$. After about two hours charging with a current density of 1 amp per square centimeter in an electrolyte of 25 per cent alkali, the electrode is ready for use. (917,875, April 13, 1909.)

RECENTMETALLURGICAL PATENTS.

Zinc.

Silicon as Reducing Agent.—Mr. A. G. Betts, the pioneer of electrolytic lead refining, is now directing his attention to zinc. His latest invention in this field contains nothing of an electrometallurgical nature, except the use of silicon as reducing agent, silicon being a product of the electric furnace. The process is stated to be especially applicable to zinc ores containing impurities, like iron or lead. The ore before or after roasting is mixed with silicon or a silicon alloy, as high-silicon ferrosilicon, in quantities sufficient to reduce the contained acids of zinc, copper, lead and iron, and the mixture is heated in a reverberatory furnace, but not to the temperature at which the reduction of zinc takes place. This heating can be safely done in the air or in the furnace gases without serious oxidation of the silicon. The heated mixture is passed into a highly heated furnace chamber, wherein the charge heats up further and the reaction commences and goes on. The heat of reaction is large and thereafter the amount of heat required to maintain the smelting temperature in a furnace chamber to which the ore and silicon mixture is added continuously or at intervals, while slags, etc, are tapped off, is largely reduced or entirely done away with. The distilled zinc is condensed with a suitable condenser. In distinction from the usual process, the presence of elements in the ore which yield liquid smelting-products is not disadvantageous, as any liquid products may be tapped from the furnace. The unoxidizability of the reducing agent used, except at very high temperatures, in distinction from the carbon hitherto used, allows of the ready and economical preheating of the charge by ordinary furnace methods. (918,648, April 20, 1909.)

Furnace Construction.

Roasting Furnace.—As much has been heard in recent years of the Wedge roasting furnace, a recent patent of Utley Wedge is interesting. Fig. 1 shows a vertical section of a five-floor furnace and a horizontal section along the line *a a*. Annular roasting chambers 1 surround the revolving central shaft 2 with stirrer arms 10 with depending blades or rabbles 11 The stirrer arms 10 pass through the metallic shell of the hollow shaft 2 and are supported upon stuffing boxes 13. The ends of two opposite arms within the shaft are bolted together, so that each pair of arms constitutes a unit. Each of the arms 10 is hollow and has a longitudinal partition 14 extending part way through it in order to form passages 15 and 16 which communicate with each other through a common chamber 17 at the outer end of the arm. Both of the passages are continued into that portion of the arm which projects into the hollow shaft 2, the passage 16 being in free communication with the interior of said shaft, and the passage 15 communicating with a vertical pipe 19 which extends to and through a diaphragm 20 located below the top of the shaft 2. The pipe of each arm, therefore, discharges into a chamber 21 contained within a casing 22 at the top of the shaft. This chamber discharges through a suitably sealed neck into a take-off pipe or stack 24. Through the pipe 30 at the bottom, a flow of air is induced by means of a steam jet 31 or the like. A constant supply of air is thus maintained within the hollow shaft 2, which can be maintained under

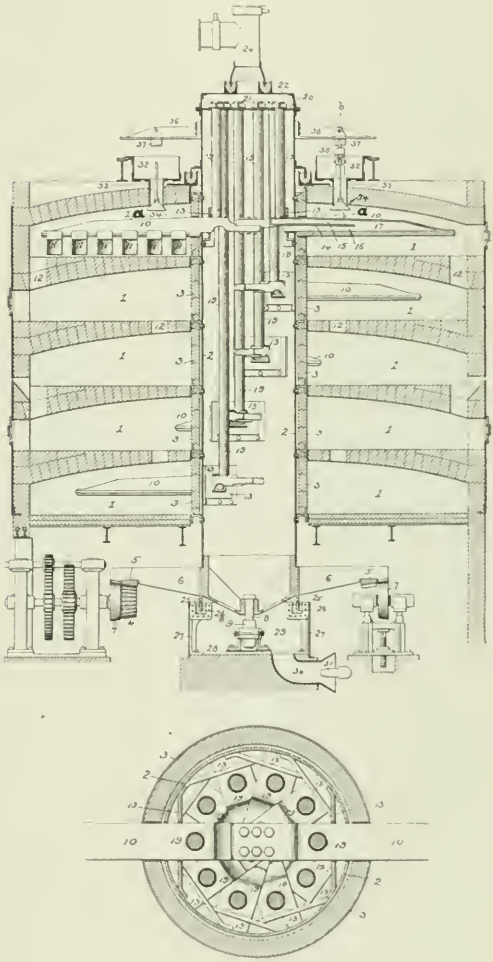

FIG. 1.—ROASTING FURNACE.

light pressure if desired. The air has free access to the inner ends of the passages 16 of the various stirrer arms, but can only escape from the passage 15 of each arm through its corresponding pipe 19. Consequently the circulation through each arm is entirely independent of the circulation through any other arm of the series, and is maintained under the same conditions as to all of the arms, so that the circulation must necessarily be uniform throughout the entire series of arms. When air is used as cooling medium, the heated air is taken out through the take-off pipe at the top of the shaft, and may be utilized. The material to be roasted is fed into the annular trough 32 at the top and then passes through necks 33 into the upper chamber of the furnace. (916,234, March 23, 1909.)

A Comparison Between Welding Systems.

The subject of autogenous welding—more particularly by means of the oxy-acetylene blowpipe—has now become of general interest to engineers, chemists, metallurgists and others, owing to the extreme flexibility of the process and the great variety in the nature and shape of the materials which can be successfully united by this means.

So far most of the articles which have hitherto been published have dealt almost exclusively with one or another from of apparatus, and but little has been written about the physical aspects of welding from a technical point of view.

Through the courtesy of the Linde Air Products Company, of Buffalo, we are now able to place before our readers some authoritative notes, for the most part based on some years' experience of the process, which have been compiled by Mr. K. S. Murray, and present the subject in a new and instructive manner.

In every process of welding, internal strains are inevitably set up. These are due to the fact that metal expands when heated and contracts when cooled, so that when two pieces of metal are welded together locally, either by simple fusion of the parts or with the addition of molten metal, contraction occurs as the metal cools. Where these parts form restrained members of any structure the internal strains produced are often sufficient to crack the metal.

This is more especially the case when welding is employed on hard, brittle or inelastic material, such as cast iron, and the tendency to fracture is greatly increased if the cooling of the metal after welding is conducted rapidly or irregularly. The magnitude of the forces which bring about this fracture in cast iron may be estimated by the rules for contraction which hold good in foundry practice, because in simple fusion-welding the physical conditions of expansion and contraction in and around the weld are not dissimilar to those of the foundry.

Whenever local strains exceed the strength of the metal a fracture must inevitably occur. These strains, however, often remain latent within the metal, so that the fracture may not actually take place until brought about by some external cause such as a light blow or even a current of cold air. The less brittle a metal naturally is, or, in other words, the more ductile it is, the better is it capable of withstanding internal strains of this description. The sudden cooling of any metallic body which has been welded should be scrupulously avoided.

In order to relieve a welded piece of metal from internal strains due to welding, it is desirable not only to pre-heat the whole of the part when possible, but also to re-heat it after welding to a cherry-red heat. This causes molecular rearrangement to take place within the metal, which will bring about a distribution, if not an actual dispersion of internal strains. In the case of cast iron this treatment is imperative where a repair is effected in a restrained member of the structure, and not only should pre-heating and re-heating (or annealing) be always employed, but the raising and lowering of temperature in so doing should be slow, and the casting should be kept entirely free from air draughts, or other extraneous cooling effects. This treatment is less essential for steel, but it can never be other than beneficial.

Unfortunately, for large work it is generally impossible to anneal the whole structure in this way. In such cases it is a useful makeshift to heat the plate for a considerable area round the weld, both before and after welding. It is obvious that the nearer the temperature of the whole structure can be brought to the fusion temperature required for a local repair, the less will be the excess of expansion at the welded point, and consequently the less will be the local strain set up at this point when the structure cools. Too much attention cannot be paid to this physical aspect of welding, and even when the process of fusion-welding is employed to fill up flaws in castings, it is desirable when possible to heat the whole structure before and after treatment.

The oxy-acetylene system of blowpipe welding is employed in two forms, which may be described as the high- and low-pressure systems.

The first to be introduced was the high-pressure system, in which both gases are delivered to the blowpipe under pressure. Oxygen is supplied from an ordinary trade cylinder and acetylene from a cylinder in which it is dissolved in a porous material soaked in acetone. Acetone is a liquid hydro-carbon which has the property of absorbing 25 times its own volume of acetylene at atmospheric pressure, and it continues to do this for every atmosphere of pressure that is applied to the gas. It was soon found, however, that the cost of using dissolved acetylene in this way was so high as to be almost prohibitive, except under special conditions, and the high-pressure acetylene generator was then evolved, to take the place of the tank of acetylene.

Of the two systems the low-pressure system of welding has undoubtedly been most generally adopted and is now gradually superseding the older system. In the low-pressure method only the oxygen is required under pressure. Acetylene may be taken from an ordinary generator of approved design. The size of the acetylene generator employed is, however, a matter of much importance in relation to oxy-acetylene welding. It may be taken as a general axiom with regard to acetylene that the more rapidly heat is generated during decomposition of the carbide, the more impure will be the acetylene produced and the worse the welding which will be effected with the gas.

If the decomposition of the carbide is effected with a restricted quantity of water, the heat evolved at the actual point of decomposition is so great that the acetylene itself becomes disassociated and re-forms into various hydrocarbons, which, when once formed, cannot afterward be eliminated without loss of acetylene. Furthermore, these hydrocarbons require more oxygen for their proper combustion than does acetylene, and consequently when they arrive at the blowpipe, then the proportion of oxygen which is correct for the proper combustion of acetylene becomes insufficient for the complete combustion of other hydrocarbons. On the other hand, if decomposition is slow, these difficulties do not arise.

A generator of adequate proportions, together with a holder of ample size for the gas consumption required, is, therefore, a most important desideratum in the selection of an acetylene plant for oxy-acetylene welding. The generation of acetylene should be both slow and regular.

In a properly proportioned welding equipment decomposition of the carbide takes place in such an excess of water that the heat evolved under ordinary working conditions is never sufficient to cause the above trouble.

The illustration (p. 227) shows a complete low-pressure welding installation of this type. The acetylene generator is entirely automatic, the absence of any positive feed mechanism being of great advantage. No motive power of any kind is required to operate the plant.

The temperature of the flame in a good oxy-acetylene blowpipe is approximately 6000° Fahr. This high temperature is mainly brought about by the combustion of carbon to carbon-dioxide. The chemical combustion of acetylene and the physical conditions which arise during its combustion in oxygen differ essentially from those which occur in the case of hydrogen.

Acetylene has a heating value of about 1500 B.t.u. per cubic foot. It is approximately composed of 92.5 per cent carbon and 7.5 per cent hydrogen, which in combustion with oxygen form carbon-dioxide and water. In consequence of the high flame temperature, however, the water formed by this primary combustion is dissociated into hydrogen and oxygen, the latter element combines at once in the flame with the carbon of the acetylene to form carbon-dioxide, while the hydrogen can only combine with oxygen which has passed out to the hottest zone of the flame, and thus does not involve a consumption of heat at the expense of the hottest part.

It is, in fact, claimed for oxy-acetylene welding that the hydrogen forms a relatively cool jacket round the hot flame produced by the combustion of carbon in oxygen, and that as the hydrogen is not able to combine with oxygen at the very high temperature which exists within the inner zone, but remains temporarily in a free state, it protects the inner zone in a measure from loss of heat, while largely excluding the tendency to oxidation of the metal—a defect from which all other methods of welding suffer. With the oxy-acetylene flame it is even claimed that burned or overheated metal is not likely to exist, because oxidized metal is not stable at such high temperatures and must, therefore, be reduced to a metallic condition.

The strength of the weld produced by the flame is almost invariably somewhat less than that of the original material. This may be due to the use of welding strips of inferior tensile strength, or to those internal strains which have already been referred to. It is also undeniable that the structure of the material in the weld is less homogeneous than in other parts. This, however, is largely a matter of skill on the part of the individual welder. It is possible for a competent welder, at his discretion, to give a greater or less strength to the welded part, and for this reason it is impossible to draw conclusions from the work of one man as to the work of another.

Oxy-acetylene welding must be regarded as a trade which can only be mastered by intelligent work and gradual development from simple to difficult jobs. Much depends on the intelligence and ability of the workman. A skilful welder will use a hammer freely as well as a blowpipe, more especially on vertical or overhead welds in plates which are subsequently to be subjected to pressure strains. By the judicious use of hammering at the right moment on the welded part, the metal can always be made denser, with the result that the strength of the weld is increased.

When the **oxy-hydrogen** flame is used for welding purposes the oxygen and hydrogen are generally produced by the electrolysis of water. Therefore their combustion may be described as the last stage in the cycle of change which the water has undergone. Hydrogen and oxygen have a strong affinity for each other, and their combination occurs with great explosive violence, the product being water in the form of steam. This steam is, of course, superheated in the hot zone of the flame and as steam is not stable at high temperatures it is bound to be re-decomposed into its elements in the flame. This decomposition or disassociation will begin at a temperature below 2000° Fahr., and continue with progressive violence until the temperature has reached 4500° Fahr., above which temperature the existence of steam as such in the hot zone of the flame is altogether impossible.

The process of dissociation involves a consumption of heat which is abstracted from the flame itself, and it leads to the existence of free oxygen in the flame, with consequently an oxidizing effect on the weld. This can only be avoided by feeding into the flame a large excess of hydrogen (in practice from four to five volumes of hydrogen to one volume of oxygen), while, on the other hand, only the amount of heat can be obtained which is disengaged by the combination of two volumes of hydrogen with one volume of oxygen.

The large excess of hydrogen required to prevent oxidation furnishes in itself one reason why welding by means of the oxy-hydrogen flame is frequently uneconomical. A further reason, however, lies in the fact that the temperature of the flame, in consequence of this, is essentially lower than it ought to be. Materials to be welded are usually good conductors of heat, and as the local heating of the body to be welded is a physical process which requires a certain amount of time, the quantity of heat lost by conduction in a body of the metal will be obviously all the greater the lower the temperature of the flame.

Hydrogen in combustion yields heat to the amount of 350 B.t.u. per cubic foot, but as at least four volumes of hydrogen must be employed with every volume of oxygen, for welding purposes, the true calorific value per cubic foot is about 175 B.t.u. as compared with 1500 B.t.u. in the case of acetylene.

In this country oxy-hydrogen welding has never been employed to any appreciable extent. On the Continent of Europe, however, it has been in extensive use for a number of years. The process grew out of the introduction of electrolytic plants for separating oxygen and hydrogen from water. It became necessary to find an outlet for the hydrogen produced by this process in order to be able to sell oxygen at remunerative prices, and the oxy-hydrogen process resulted from this.

WELDING WITH THE OXY-ACETYLENE FLAME.

The introduction of the oxy-acetylene welding process in more recent years has not only checked the development of the older process, but, in fact, to a very large extent has entirely superseded it.

Another very important factor which militates against the successful development of oxy-hydrogen welding is the quality of the oxygen. It is practically impossible to provide against the presence of a varying percentage of hydrogen in electrolytic oxygen and an element of danger is thus introduced which does not exist in the case of oxygen produced by other means.

It has been stated that **electric welding** is more efficient and economical for most purposes than oxy-acetylene welding. This is, however, not strictly correct. The first cost of an electric-welding apparatus is incomparably greater than that of an oxy-acetylene welding apparatus. It is also far less portable, and its scope is consequently more restricted. There are certain applications for which electric welding may be more suitable, but for ordinary every-day work there can be no doubt that the oxy-acetylene system is much to be preferred for the following reasons, apart from the question of cost:

In welding with the electric arc heat must of necessity be concentrated upon one point, viz.: that to which the temperature of the arc is imparted. In oxy-acetylene welding, on the other hand, the heat can be brought to bear at will on the surrounding material. The correct welding temperature can thus be gradually attained at any desired point.

In electric welding any unsteadiness of the hand will at once strike the arc between the two carbon points, and will thus cause an addition of fused material to the bulk of metal where it is not required. In the oxy-acetylene process material can be gradually built up as desired exactly on the part to which the flame is being directed.

In electric welding the arc is formed at the expense of atmospheric oxygen, and this fact indicates that chemical changes of an oxidizing character must take place in the welding part. In oxy-acetylene welding, as already stated, the welded part is surrounded by a shield of hydrogen, which tends to isolate atmospheric oxygen from the part being welded.

In electric welding a fairly stout iron wire must of necessity be used to serve as a pole of the electric arc, whereas in oxy-acetylene welding thin wires can be employed, and these are found by experience to be most suitable for the work.

In electric welding the size of the drop of fused metal added in building up the weld is not within the control of the welder to anything like the extent it is in the case of the oxy-acetylene welder.

Finally—and this is perhaps the most important point of all—in electric welding any subsequent treatment of the welded place, such as gradual annealing of the area surrounding the weld, is impossible. In oxy-acetylene welding this can be done with ease and, as already pointed out, it is just this subsequent treatment of the welded part with a view to removing internal strains and depriving the weld of its hard and brittle character, which forms the special merit of oxy-acetylene welding in large and restrained structures, such as boiler flues and similar apparatus where homogeneity of the metal is a matter of utmost importance.

As illustrating the relative efficiency of oxy-acetylene and electric welding it is of interest here to quote tests published by Mr. Ruck-Keene, the principal engineer surveyor of Lloyds, in an instructive paper read by him before the members of the Institute of Marine Engineers on Sept. 28, 1907. The material operated upon was in each case the same, and it is important to note that while in the case of electric welding the ultimate tensile strength is somewhat greater than that obtained by oxy-acetylene welding, the ductility of the metal in the latter case is considerably better. The tests are, however, of chief importance as indicating the value of annealing.

OXY-ACETYLENE WELDING

	Breadth	Thickness	Area	Tons Total	Tons per Sq. In.	Extension in 4 Ins. per Cent.	
	Inches	*Inches*	*Inches*				
Not annealed	1·5	0·2	0·3	22·85	24·5	30	Solid plate.
Annealed	1·5	0·2	0·3	22·35	24·0	36	
							Extension in 8 Ins. per Cent
Not annealed	1·5	0·2	0·3	22·9	24·6	28	Broke away
Annealed	1·5	0·3	0·45	22·1	23·3	20	from the weld

COLD BENDS

Not annealed	180°
Annealed	180°

ELECTRIC WELDING

	Breadth	Thickness	Area	Tons Total	Tons per Sq. In.	Extension in 4 Ins. per Cent.	
	Inches						
Not annealed	1·0	0·6	0·6	15·35	27·4	12	Broke
Annealed	1·0	0·5	0·5	14·5	26·3	14	through weld.

COLD BENDS

Not annealed (signs of fracture at weld)	58°
Annealed	100°

Increasing the Efficiency of Plate Amalgamation by Electrochemical Action.

By Elmer Ellsworth Carey.

Within the last decade the problem of using electricity in a practical and efficient manner in the extraction of metals has received the earnest attention of many investigators.

One of the first applications of electrochemistry to the modern metallurgy of gold was the electrolytic precipitation of gold from cyanide solutions.

Turning to amalgamating practice, it may be said that electrochemical methods may now be successfully used in connection with the usual battery plate. After a long series of experiments, extending over a score of years, a very simple method of converting the standard plate into an electrochemical amalgamating device of remarkable efficiency has been devised. The electrochemical system of amalgamation is designed to extract from the sands or pulp all gold values not encased; it is an entirely new system of amalgamation, designed to do the work of the ordinary mill plate, including the treatment of slimes, and at the same time to extract values which cannot be saved by the usual mill practice and which otherwise would require cyanide treatment; to do all this in one single, inexpensive and continuous operation, requiring practically no more outlay for installation and maintenance than the usual mill plate.

The system also furnishes a method by which the Alaska beach deposits, black sands, hydraulic placer and dredge tailings, mill tailings, desert deposits and many low-grade propositions can all be profitably worked. The broad claim made for the electrolytic system is that it will save all values not encased.

Preliminary Treatment.—It may be sometimes necessary to grind ore or sands to 100, 150 or even 200 mesh, before the values are released, but after this has been done the pulp is simply passed over the amalgamating device, by which, with the aid of electrochemical action, the gold is extracted to such an extent that usually no further treatment is profitable. In ordinary cases, values are recovered at 80 mesh. In certain cases where the ore is unusually refractory, base or rebellions, it may be necessary to treat the tailings for an hour or two by the continuous electro-cyanide process, which is an exceedingly simple and inexpensive operation, but withal very efficient.

Apparatus.—This method of gold recovery calls for a sluice box of suitable width, the length being 40 or 50 ft., or even longer, according to conditions. In the bottom of the box is an ordinary copper plate acting as a cathode. Graphite anodes are employed. Direct current of low voltage is used, passing from the grapite anodes through the solution to the amalgamating device and the copper cathode plate. Pulp of proper fineness, screened gravel or sand is passed into the device.

Essential Elements of the System.—The anodes and cathodes are connected with a generator in the usual manner, the voltmeter, rheostat and ammeter being in place. The current density is approximately one ampere per square foot of cathode surface.

In operating the mercuric salt solution is mixed with the water passing into the device. The amount of the solution, which is standardized, depends upon the values in the pulp. Several reactions are simultaneously going on, of which we will now mention the more important ones.

Deposition of Mercury.—There is a constant and uniform deposition of "virgin" (nascent) mercury on the cathode plate, so that the cathode plate is covered with a bright, shining and chemically pure coating of mercury, which remains in a perfectly "healthy" state as long as working conditions continue. The deposition of mercury and the character of the amalgam are at all times under absolute control of the operator. The mercury coating or plating adheres tenaciously to the copper plate, and the passing volumes of water, sand, pulp, etc., have no effect upon it. When no gold is present in the gangue after

a certain amount of mercury has been deposited, no more mercury will adhere, but any excess will collect in globules and be carried over the plate, which is amply provided with mercury traps at the lower end. But with proper adjustment, no excess of mercury is possible, and no "floured" mercury is discernible in panning the tails. This coating or plating of mercury above mentioned will stand the action of a heavy volume of running water containing a full load of pulp; even water carrying a full load of magnetic iron has no injurious effect on it.

Mercury deposited by the electrolytic action withstands the erosive action of a heavy volume of water (200 gallons per minute and black sand containing 66 per cent iron; at one time 40 tons of black sand were used to test this matter, and the fact is as above stated.

By continually reproducing the mercury cathode surface by electrolytic deposition its amalgam-forming powers are intensified to such a degree that rusty, greasy or pyritic gold is instantly amalgamated; platinum is absorbed as quickly as gold when sodium is present in the amalgam (see below under sodium amalgam). Grease, talc, silicious coatings or sulphurous conditions in connection with gold particles have no effect in preventing amalgamation, and "fouling" or "sickening" of the plate is impossible. The use of electrolytic amalgamation insures a constantly bright, healthful and powerfully active mercurial surface, impossible under the usual practice. The behavior of the mercury under electrolytic conditions is entirely different from its action in ordinary amalgamating practice; and conclusions based on the usual behavior of mercury will not apply in the new method.

"Nascent" Hydrogen.—Hydrogen at the moment of its liberation from a compound is often called nascent hydrogen, and is in this condition very effective as a reducing agent; it destroys instantly organic, greasy and foul conditions; it unites instantly with the oxygen of iron rust at ordinary temperatures, thus cleaning "rusty" gold, and the action of nascent hydrogen on the mercury is such that fouling of the plates cannot occur.

The action of nascent hydrogen as a cleanser and reducing agent is used to advantage in the electrochemical amalgamator, and if the gold particles are unusually coated or rusty additional volumes of hydrogen can be obtained through electrolysis by adding some inexpensive solution of a potassium or sodium salt. Under the action of electrolysis the mercury as fast as deposited absorbs free hydrogen, which is occluded throughout the whole mass of mercury; and the gas is all the time exercising a powerful cleansing and reducing effect and preparing the way for amalgamation. Under these condition mercury is in the best possible condition to form amalgams.

Formation of Sodium Amalgam.—When sea water is used in the electrolytic system of amalgamation, or when a solution of common salt, or some solution containing a sodium salt, is mixed with the water entering the device, we have also the deposition of metallic sodium, which alloys with the mercury, and a sodium amalgam is formed. Sodium amalgam will hold free gold in any condition; also platinum; at least hydrogen sodium amalgam will amalgamate all metals not encased, which are in a comminuted state, and sodium amalgam by electrolysis cannot be made without the presence of hydrogen.

Hydrogen Sodium Amalgam.—In Vol. I, *Proceedings* of the (London) Inst. Min. and Met., page 205, P. G. Warnford Lock describes the formation of hydrogen-sodium amalgam and mentions the powerful affinity between this amalgam and gold. In electrolytic amalgamation the hydrogen is formed in several ways. Part of the hydrogen liberated forms hydrogen-sodium amalgam, and part is used in reducing oxides, which form rusty coverings on gold particles; parts also act as a general cleanser and purifier as it escapes through the water.

Formation of Gold Amalgam.—We have seen above how the presence of hydrogen and sodium prepares the way for amalgamation. So well has the work been done that amalgamation takes place as soon as a particle of gold touches the quickened mercurial surface. And it might be noted in passing that amalgam formed under the conditions which we have described (electrolytic amalgamation) is a different compound from the usual amalgam formed on mill plate. The amalgam as described holds to the plate very tenaciously and is not easily dislodged. It is homogeneous and free from foreign materials. Particles of amalgam under this system are not broken off by the passing volumes of water.

The larger particles of gold will come in contact with the mercury before passing many feet; microscopic values or float gold, or values in slimes, will require a longer length of cathode surface; at times possibly 40, 50 or even 60 ft. will be required, but any microscopic particles, or any of the values in slimes will be instantly arrested at the first contact with the mercurial surface. Experiment has demonstrated that electrolytic amalgamation will recover from 95 to 99 per cent of all gold not encased. When pulp is ground to 100 or 200 mesh, the tailings after passing the electric amalgamator do not contain enough values to make any form of supplementary gold devices necessary.

Chlorine Gas.—Nascent chlorine is liberated at the anode when common salt or other chlorides are electrolyzed in solution. The chlorine dissolves in the water. Water saturated with chlorine and the further chlorine compounds which may be found have a bleaching and cleaning effect.

Electrolysis of H_2O.—The decomposition of water has been mentioned with the evolution of free hydrogen at the cathode. At the anode oxygen is liberated, which also assists in preparing values for amalgamation, as it is a powerful enemy of organic substances, and foul, greasy or dirty conditions are quickly eradicated by its action.

Mechanical Action of Gases.—At all times there are liberated from every portion of the surface of the cathode free gases, which rise upward through the water. These constantly escaping gases have a tendency to act as a cushion over the newly formed amalgam, which cushion prevents in a measure any scouring effect on the part of both sand or gravel, thus rendering the system equally applicable to stamp mills, placer mines, gold dredges and beach mining. Gravel and black sand can be passed over the device and freed from all values, no matter how small, which may be present.

"Dynamic Electrical Action."—The claim is made by the inventor of this system that "a critical electrical current when properly adjusted tends to force all gold particles to the cathode plate, and that such current actually does carry microscopic particles into contact with the mercury: and that the efficiency of this force depends upon density, voltage and proper adjustment of the device." There is considerable evidence to support this contention that there is a dynamic action in the electrical current that carries gold particles to the cathode. As a rule, all values are deposited in the mercury in the first 10 or 12 ft. of plates; and it is hardly reasonable to suppose that gravity alone would be sufficient to force every particle of gold into an amalgamating contact in such a volume of water as is used. If the necessary contact for amalgamation was the result of chance and gravity, it would be reasonable to look for an occasional color in the tailings; but not only is it impossible to find a color there by the most careful pannings, but it is impossible to find any value of importance by the most careful assay.

Conclusion.—In the system of gold extraction above outlined, amalgamation proceeds under the most favorable conditions that can be provided. Every obstacle is removed, and every force that tends to assist is intensified and reinforced. Not in a laboratory could a more positive action be obtained. Instead of leaving the amalgamating process to chance and the uncertainties of the usual practice, with all attendant difficulties,

we have in the process in question the formation of amalgam carried on under ideal conditions, where the highest possible efficiency is attained; and it should be remembered that the processes and forces which deposit the mercury and gold in the form of amalgam are constantly striving to hold the amalgam in place, and to resist any erosive tendencies of the water and pulp. In view of these facts, it is not unreasonable to hope that electrolytic amalgamation may come into extended use, and at the same time vast fields be opened for the miner which are now beyond his means.

The only special machinery required for the electrolytic system of amalgamation is a low-voltage generator, requiring from 2½ to 5 hp for operation. A 5-hp generator will furnish sufficient current for the treatment of 500 tons daily.

San Jose, Cal.

Thermit Welding on the Pacific Coast.

The thermit process, the principles and general applications of which are so well known to our readers, is constantly being called upon for repairs which are decidedly out of the ordinary. That is one reason why the process is so interesting to follow and why those who once adopt it become so enthusiastic over it. Two repairs carried out by the Pacific Coast branch of the Goldschmidt Thermit Company, of New York City, may be described.

An instance occurred last December, in San Francisco, which

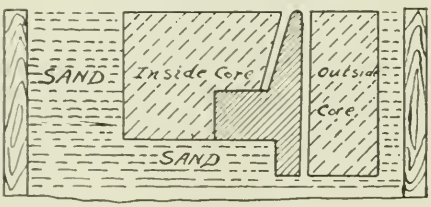

FIG. 1a.—CROSS SECTION THROUGH MOLD AND RING, SHOWING ARRANGEMENT OF CORES.

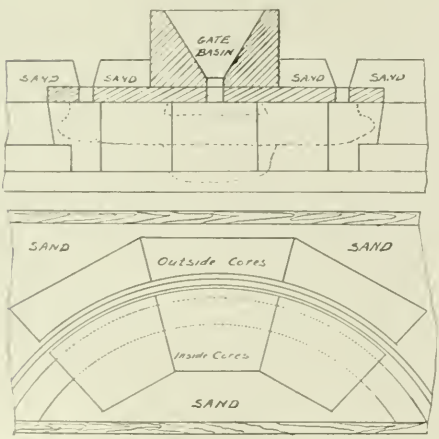

FIG. 1b.—TOP VIEW AND LONGITUDINAL SECTION.
(Dotted lines show where metal was cut away, preliminary to welding.)

is certainly different from any thermit repair heretofore attempted. It was found that the end of a commutator ring was frozen into the copper commutator of a large generator belonging to the San Francisco Gas & Electric Company. A good deal of the copper had formed a very hard alloy on the surface of the ring, and it was necessary to cut out 24 in. of the circumference, as shown in Fig. 1, and weld in a section of thermit steel to replace that cut away.

The difficulties to be encountered in making such a weld, made the job appear a desperate one, but owing to the fact that the generator was very badly needed, it was resolved to undertake the repair.

It was impossible to use the wax method, described in this journal, Vol. VI, p. 166, in this case, as there was no compressed

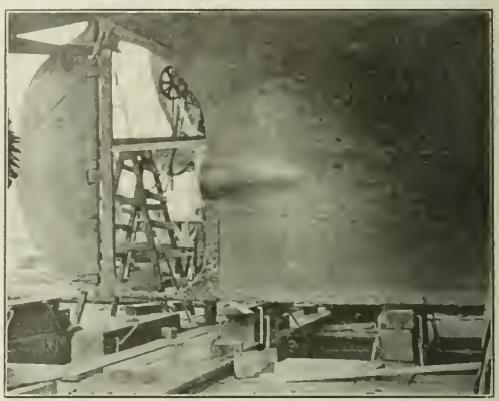

FIG. 2.—STERN FRAME TO BE REPAIRED.

air available. Furthermore, it would have been extremely difficult in any case to hold so much wax (a section 24 in. long) in position against the tamping. It was decided, therefore, to make cores both for the inside and outside of the mold by building corresponding boxes of wood and using a good part of the ring as a pattern, extra space being allowed for subsequent finishing off. This extra space was gained on the inside by some flat pieces of rubber which were at hand, and for the outside a heavy sheet of asbestos was used, covering the face of the ring. Three cores in all for the inside and an equal number for the outside were required. The top was covered by cake cores and basins were formed for the running gate and for the overflow to the risers—one at each end.

The heating was done by removing these cake cores, which exposed the metal of the ring to the direct flame of the torch. When the surfaces had been brought to the proper temperature the torch was removed, the cake cores replaced and the thermit steel tapped into the mold. Ninety pounds of Thermit, 12 lb. of punchings, 3 lb. of borings, and 12½ oz. of pure manganese were required for the weld.

The metal obtained was very good and tough and of medium-fine grain. About an hour after the pour the mold was dismantled and the ring sent to a nearby machine shop to be finished. The finishing showed that good fusion had taken place between the thermit steel and the steel of the ring and the repair was, therefore, a success.

Another interesting repair carried out recently on the Pacific Coast by the thermit process was the welding of a new skeg in the stern frame of the United States Quartermaster steamer *General McDowell*. This is a steel vessel of 160 gross tons, built in 1886 by the Union Iron Works, of San Francisco. Her dimensions are as follows: length, 125 ft.; beam, 23 ft., and depth, 10 ft. 6 in.

The operation consisted in cutting out the old skeg and replacing the same with a new piece, the welding of this new piece having been ordered by the Government authorities at Washington to be performed by the thermit process. Fig. 2 is a general view of the stern frame of the steamer, giving a good idea

of how badly worn the old skeg was. To strengthen it, an iron shoe had formerly been fitted and riveted to the skeg, and the holes seen in the picture are the rivet holes used for this purpose. Fig. 3 shows the new skeg, just having been put in place before having been properly supported or secured. It also shows the space on each end of the skeg between the old work and the new.

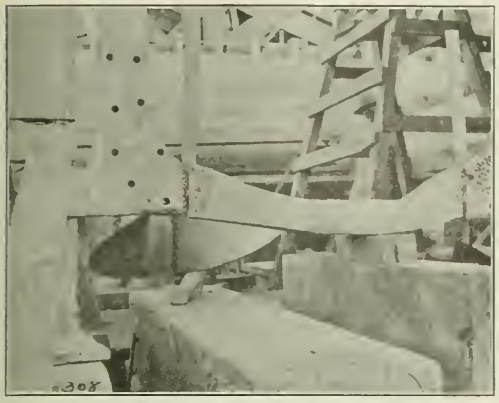

FIG. 3.—NEW SKEG PUT IN PLACE.

The new skeg was first forged of iron to the proper shape and placed in position, so that grooves cut fore and aft corresponded to similar grooves in the ends of the stern frame. The object of these grooves was two-fold: first, to form a key for the thermit metal, and, secondly, to hold a gib, in order that the skeg might be secured in place temporarily while the mold was being rammed up. A common mold box for the two welds was constructed and a wax pattern formed around both ends of the skeg. When this had been completed, the gibs above mentioned were withdrawn with great care and the ramming of the mold completed. This work required one day for its completion and the next day the actual welding was undertaken.

As in the case of the commutator ring, it was necessary to preheat these sections before pouring in the thermit steel and a gasoline torch was accordingly set going to accomplish this result. While the heating was in progress, the charge of thermit for the first weld was placed in a crucible suspended over the pouring gate of the mold.

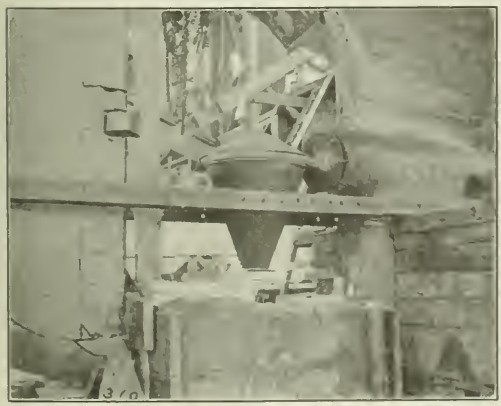

FIG. 4.—VIEW AFTER COMPLETION OF SECOND WELD.

Altogether this weld required 184 lb. of thermit, 40 lb. of mild-steel punchings and 4 lb. of pure carbonless metallic manganese. When the sections had been brought to a red heat, the torch was withdrawn, the heating gate plugged up and the thermit ignited in the crucible. At the end of the thermit reaction the steel was tapped into the mold, where it filled the space previously occupied by the wax.

A second weld was made in the same manner and required 150 lb. of thermit, 30 lb. of punchings and 3 lb. of carbonless manganese.

Owing to the fact that there were two breaks, it was necessary to move the crucible and a very ingenious apparatus was constructed for this purpose. The crucible was placed in a little frame on wheels, which enabled it to be very easily shifted fore and aft and after the first weld was completed the crucible was not raised or lowered, but was simply moved bodily, with frame and supporting angle irons, from the starboard side of the ship to port, so as to be in proper position for the gate of the second weld.

Fig. 4 shows the condition of the work after completion of the second weld. It shows *the box built* around the whole length of the skeg. The fire brick on top of the mold formed a little wall built up and luted to prevent an overflow of slag from the first weld into the after mold. The picture shows the crucible supported on angle iron, and the protection of the stern sleeve by a plate against the spatter of thermit metal or slag. Above the crucible may be noticed the corner of an iron plate. These plates were secured under the counter of the vessel to protect it from the action of the crucible.

FIG. 5.—COMPLETED WELD WITH GATES AND RISERS

The day following the completion of the two welds the mold was dismantled. Fig. 5 shows the completed weld with gates and risers. The metal which had been left in the gates and risers was then removed and the welds were then tested by the chief engineer and found to be perfect.

It might be pointed out here that had this repair been made by any other method it would have been necessary to remove the entire stern frame from the ship—an operation of considerable magnitude, as all the plates are riveted to the frame and would have had to be cut loose, after which the welds would have had to be made in the forge and the frame replaced. By utilizing the thermit process, however, such repairs as the above may be carried out in from two to three days and on their completion the vessel is ready to be placed in immediate service.

The Standardization of Refractory Materials.

In the (London) *Electrical Review* of March 19 we find the following notes, which should also be of interest to American users and makers of refractories:

An important movement has been set on foot at Stoke-on-Trent, under the auspices of the English Ceramic Society, having for its object the arrangement of an agreement between technical institutes and societies representing various important industries, for the grading and standardization of refractory materials, such as fireclay and magnesite, used in the construction of furnaces, kilns, ovens, etc. The importance of any advance in the direction of making refractory materials more resisting to high temperature has often been commented on; in Germany there exists a recognized center to which one can refer for unbiased reports as to the qualities of refractory materials, but in Great Britain and in France research of this character is in a very backward condition.

Dr. J. W. Mellor, Staffordshire County instructor in pottery and honorary secretary of the English Ceramic Society, has now taken the lead in initiating a movement to deal with the subject, and as the result of a circular sent out a meeting was recently held at Stoke-on-Trent, at which there were present representatives of various industries from all parts of England.

As the result of the deliberations of the conference it was decided to form a body to be called "The Center for the Standardization of Refractory Materials" and the objects of the committee were embodied in the following preliminary program: (a) To arrange and classify the various refractory materials—clay siliceous, as silica and ganister; special, as magnesite, chromite, etc.; (b) to arrange standard specifications for the raw materials and for the manufactured products; (c) to consider the possibility of arranging for uniformity in certain "stock" or "standard" sizes, and (d) to agree upon standard methods of testing, analysis, etc.

To carry out this scheme it was agreed that the representatives of the institutes should consult with their respective fellow-members, and whenever possible procure information bearing on their specific requirements, together with data as to furnace temperatures and conditions of operation. Each section will at first conduct its own part of the inquiry independently of the others and prepare a draft of their own suggestions to be submitted to the next meeting of the general committee, which will be held in some center other than in the potteries, probably in London. These suggestions will be embodied in a provisional report to be sent back to the sections for approval or amendment and finally published as a general report. It is proposed to revise this report periodically to keep abreast of developments. Arrangements are being made in France, Germany and America to ensure that the method ultimately arrived at shall be international. The negotiations with America are already in an advanced stage. Dr. Mellor has been inundated with correspondence by manufacturers since the initiation of the movement, which will probably lead to a very great advance in the quality of the finished products.

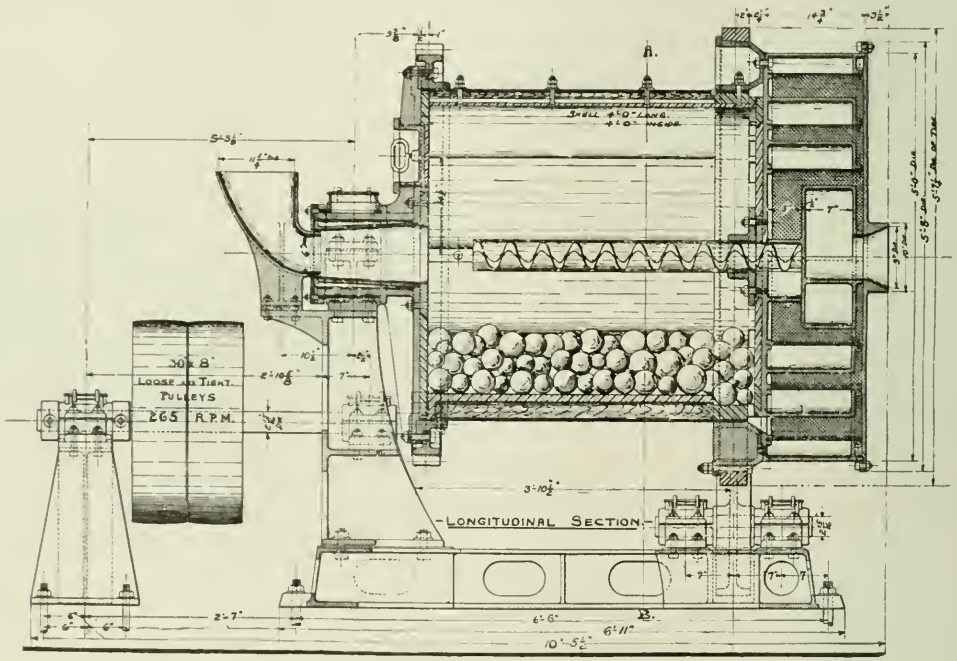

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FIG. 1.—SECTION OF BALL MILL.

Ball Mills.

Ball mills are very extensively used in various industries. By a peculiar looseness of expression, no sharp distinction is often made between ball mills and tube mills. It may, therefore, not be superfluous to emphasize that ball mills and tube mills are not only two different kinds of apparatus, but serve different purposes.

Ball mills are very extensively used for preparing material to be fed to tube mills. In mining ball mills are also extensively employed for preparing ore for concentrating purposes, taking the lump ore and reducing it to 30, 40, 50, 60, 70 or 80 mesh, etc.

In the following we give a description of the Abbé ball mill

built by the Abbé Engineering Company, of New York City. It consists of a grinding chamber containing steps, which are surrounded by the steel shell, which forms the mill proper. Between the steps and the shell there are wooden pieces which fit the shell exactly and also the form of the steps, thus making a cushion that releases the effect of the jar to a considerable extent.

Onto one end of the shell is bolted the head with the trunnion and on the other end the spiral discharge and spiral screening chamber. The material to be ground is fed to the mill by means of a regular table feed and enters the machine through a pipe fastened to the trunnion. In this pipe there is a spiral that conveys the product forward into the grinding chamber,

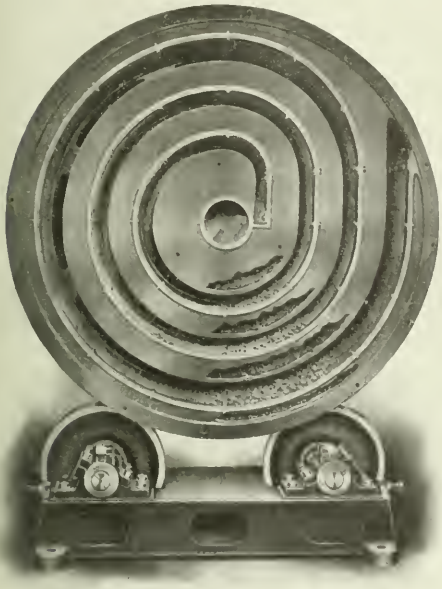

FIG. 2.—BALL MILL (SPIRAL SCREEN OPEN).

where it receives the grinding of the charge of balls while traveling the full length of the machine, so that a larger grinding capacity is obtained.

The rate at which the material is fed into the mill regulates the amount of grinding it receives and the fineness at which it reaches the screen. The faster it is fed the coarser it is discharged and the slower it is fed the longer it receives the action of the balls. The ground material leaves the grinding chamber through openings at the discharge end.

The material falls on the first turn of the screen and as the mill revolves the fine material drops through onto the discharge spiral, which conveys it to the center, where it is discharged, while the coarse particles are retained by the screen, which also forms a spiral between the spirals of the discharge, so that the tailings are carried to the center by the screen and are there returned to the grinding chamber for regrinding by a conveyor, which revolves with the mill inside.

The grinding steps in the Abbé ball mill are solid, rest on the wood above mentioned and the machine is so constructed that any one, or all of the steps, can be taken out without disturbing the entire structure of the machine, so that the lining steps can be worn down very thin before they have to be replaced.

The Abbé ball mill requires no high foundations above the floor line, as it is fed and also discharged at the center. This means a saving of a great amount of money in the first cost of installation, makes it far more accessible from every point, and causes a saving in space which is sometimes very valuable.

The screening chamber, as built and attached to the Abbé ball mill can be made of ample capacity to handle any output that the mill will produce on different materials. It can be made larger in diameter or of greater width to accommodate the variations in the output when handling different materials.

Screening in the Utah Copper Company's Mill.

By H. B. Lowden.

As originally designed and equipped the mill of the Utah Copper Company contained trommels as the main screening equipment, the undersize passing over stationary inclined screens. Each of the 12 units comprised four 48-in. x 144-in. trommels and two of the inclined flat screens, the trommels being clothed with rolled slot wire cloth equivalent to about six mesh and the stationary screens with similar material passing a product equal to about 20 mesh.

Shortly after the first units were placed in commission the usual difficulties in the operation of trommels made themselves felt and more efficient and economical screening equipment was sought; to which end a number of devices were systematically tried on a large working scale. The results of these tests were so conclusively favorable to the impact screen that it was determined to equip the twelfth unit, at that time nearing completion, with these screens and in it to demonstrate conclusively the adaptability of the machine for the work. The twelfth unit was operated with decidedly improved results, due to closer sizing, and with a capacity of 600 as against 500 tons per day of the other units owing to the tables being able to handle a greater tonnage of the more closely sized feed. The screens in this unit were running wet.

The work of replacing all the screens throughout the other units of the mill was then determined on, and has proceeded as rapidly as possible without undue interference with operations; sufficient time having now elapsed to permit of comparison between the two, the net result of the change can be summarized as follows:

The capacity of each unit has been increased from 500 tons to 600 tons per day, the tables handling the increased feed by reason of its closer sizing, and the rolls by being freed from a flood of undersize material which was formerly returned with the oversize for recrushing and which now passes through as finished product as it should. The saving of about one-quarter of the water used by the trommels, by running the four coarse impact screens, the crushing rolls and the elevator dry on the ore as it comes from the mine, this also increasing the life of the elevator from four months to eighteen months. The cost of screen cloth is in the ratio of $128 for the trommels to $14 for the impact screens.

Progress of Autogenous Welding.

By Augustine Davis.

Encouraging progress is being made in autogenous welding by the oxy-acetylene process in the United States. Cast-iron kettles, weighing approximately five tons, have been most successfully repaired where the cracks were so large that from 50 to 100 lb. of added metal was required. The welding of cast-iron automobile cylinders and aluminium gear cases has quickly become a good business wherever repair plants have been established.

Several pipe-bending concerns have installed plants to great advantage and the process is particularly valuable in the manufacture of steel window sash and frames and doors and door frames. Seamless steel range boilers are now being made so extensively that they are driving the riveted boilers from the market. One of the largest car building companies is now using the process for steel car construction. The U. S. Navy

Department has purchased three plants for use in the Navy Yards and is performing much work of value.

While there is an almost unlimited field for the process in new construction, and new uses are being discovered almost daily, the immediate demand is for repair work of nearly every character and for reclaiming defective castings.

The greatest difficulty in repairing cast iron is to overcome expansion and contraction, but ingenuity and experience have made great advances in this respect.

The development of the apparatus itself in this country has outstripped France where the process originated. The Davis-Bournonville Co., 86 West Street, New York, has constructed at Marion Station, Jersey City, a building which is devoted exclusively to the development of the art and for the instruction of operators.

To be successful the supply of gases must be unfailing; the pressures uniform and adapted to the metal to be welded and the mixtures must be most accurately maintained so that the flame may be non-oxidizing and non-carbonizing, otherwise the metal will be burned or rendered brittle. It is also necessary to have the welding materials and other supplies of the highest quality in order to attain the greatest degree of success.

The welding torch is becoming widely known as a "putting-on tool" because worn parts can be restored and new parts actually built on.

With a flame that will quickly melt any metal, furnished by a torch that can be manipulated as readily as almost any hand tool, with a supply of gases either portable or stationary, not requiring a power plant of any kind during operation, there is presented to the seeker after reduced costs and improved methods of construction, a process scarcely limited by anything other than the ability of the operator himself.

A New Type of Pyrometer for Use in Furnace Work.

The vast majority of pyrometers used in factories are used primarily to tell the operator whether the temperature of a given point is what it should be. What the particular temperature is is always a matter of secondary consideration to the workman; in fact, often it is desirable to keep him entirely in ignorance of the true temperature. Pyrometers of the conventional type emphasize first of all the true temperature, though often in disguised units, and the workman, in one way or another, must transpose this and figure how far his temperature is in error.

The Leeds & Northrup Company, of Philadelphia, has recently gotten out literature describing a style of pyrometer which the company has been making that is a striking departure from the conventional lines.

The hardening and annealing pyrometer made by this firm tells the workman first of all, and directly, what it is most important he should know, namely, that the temperature is right, or that it is too high or too low; if high or low, how much too high or too low. "Right" may be varied at will throughout any range below 1800°. The hardening and annealing pyrometer consists of three parts, the bulb, the indicator and the deflector. The bulb, suitably protected, is in the furnace, the workman watches the needle of the deflector and may or may not see the indicator.

The instrument is based on the measurement of temperature by means of the measurement of the change in electrical resistance of pure platinum. There is no cold end to attend. The scale of the deflector, which is, in reality, an ordinary voltmeter with special scale, is divided into 100 divisions, each side of a central zero. When the temperature is fifty degrees too high, the needle stands approximately on the + 50 mark; when it is seventy-five degrees too low, the needle stands approximately at —75, etc. By turning the index on the indicator, the temperature corresponding to 0 may be varied at will. Thus, if it was desired to treat a piece of steel at 1380° F., the index would be set at 1380, and the temperature of the furnace raised until the needle stood at the center of the scale. If the next piece was to be heated at 1420° F., the index would be set at 1420, and the needle again brought to the center of the scale. The ordinary thermal couple instrument has crowded on its single six-inch scale its total temperature range from 0 to 2000° F. In a given process with a given kind of iron or steel, at least ninety per cent. of this scale is without use.

On such an instrument ⅛" on the scale corresponds to 20° to 50°. On the Leeds & Northrup deflection indicator, ⅛" corresponds to 5° approximately. The workman does not have to remember at what temperature he is working. The deflection does not tell him what the temperature of the furnace is; it tells him that the furnace is so many degrees away from the correct temperature. He can at any time, by looking at the index on the box, tell at what temperature the furnace is supposed to be held. Or, should it be desired, this index may be in the superintendent's office or kept from the furnaceman's sight. In any case, the first thing that strikes the furnace-man's eye is that the temperature is higher or lower than it should be, or that it is just right, depending on whether the needle is to the right or the left of the center or just in the center.

When thirty degrees means a deflection half-way off the scale of the pyrometer, even the most careless workman will get busy to correct the error, but when thirty degrees means only a 1/16" to ⅛" motion, the average man naturally thinks "that little bit won't hurt."

It does not require a deep knowledge of psychology, and especially of the psychology of the American workman, to know that small things do not receive the consideration that big things do. With a workman reading a pyrometer, it is the amount of space covered by the needle which counts; the scale receives scant consideration. An eighth of an inch is to him an eighth of an inch, regardless of whether that eighth of an inch stands for 5° or 50°.

With the average workman the above statement is almost rigidly true; hence, a pyrometer upon whose scale an eighth of an inch equals 5° acts as an unconscious stimulant to the workman.

It is also a fact that with a pyrometer readable to 2° it is very much easier to control temperature within set limits than it is with an instrument readable to only 25°, for the reason that as soon as the source of heat, be it gas, coal, oil or electricity, begins to vary, the change is immediately noticeable and may be immediately remedied. This does not give the furnace conditions a chance to get "a set" which necessitates radical action to correct, such action starting the temperature change in the other direction.

From one point of view, a pyrometer scale resembles the thread on the gate valve of an engine; the greater the motion of the valve handle for a given change in speed, the finer may the speed be regulated; the greater the motion of the pyrometer needle for a given change in temperature, the closer may the temperature be controlled.

The measurement of temperature is in reality a problem in electrical measuring instruments, in which the Leeds & Northrup Company, of Philadelphia, has an enviable reputation.

Aluminium Welding.

With reference to the article by Mr. M. U. Schoop on aluminium welding, printed elsewhere in this issue, the following notes should be of interest as the Schoop system of welding is now being introduced into practice on a large scale in Europe.

While in all other cases of soldering and welding a most careful cleaning of the surface is necessary, this is not required for aluminium welding, if only the surface looks bright.

If sheets of medium thickness are to be welded together, the method of butt welding is employed, or the sheets are made

to overlap, and the Schoop flux paste is applied with the finger or a brush at the place where the joint is to be made. Attention must be paid to the fact that aluminium has a large condition of expansion.* For this reason sufficient space must be left in butt welding, according to the thickness of the sheets. During the welding operation aluminium is dropped on to the joint in form of wire and the like. In the case of thin sheets, it is best to bend the rim of one sheet upwards, and use the up-bent material for the joint

The greatest difficulties are perhaps found in soldering very thin sheets of aluminium of $\frac{1}{2}$ to 1 10 mm thickness (20 to 4 mils), such as are used in modern airship construction, for packing tea, cocoa, etc., for oversea transport, etc. With sufficient skill, however, even this problem may be solved. A skilled workman will also be able to make vertical or horizontal joints at will. This may be necessary in making large containers from a number of sheets.

It may finally be mentioned that Count Zeppelin has been using this method of welding aluminium since 1906 in the construction of his airships, and has stated that the joints are proving excellent and that the union is so good that the place of the joints can no longer be noticed.

In this connection it may be interesting to mention another method of aluminium welding, due to Mr. Sherard Cowper Coles, of London, who has now perfected a compact welding machine. While it is generally recognized that it is the very thin invisible oxide film on the surface which makes aluminium welding so difficult, it is interesting to note that Mr. Cowper-Coles' machine makes use of this obnoxious film in the following ingenious way:

The principle underlying the process is as follows: The ends of the rod to be jointed are butted, after facing square, and heat from a gas blowpipe or benzine lamp is applied at the joint, which rapidly produces an oxide skin, and the fused metal is retained within this skin of oxide. When the ends of the rod are molten they are brought rapidly together by releasing a spring catch. The oxide skin, bursting at the point of contact, is driven out by the pressure of the spring and the clean molten metal united and makes a perfect joint.

Notes.

New York Section American Electrochemical Society.—A well attended and very interesting meeting was held on March 27 at the Chemists' Club in New York City. Dr Chas. Baskerville was in the chair. Prof. W. D. Bancroft presented two papers, on "The Chemical Electrolysis of Acetates" and on "Electrolytic Production of Aniline." Dr. J. W Turrentine also presented two papers, on "A Modified Oxy-hydrogen Gas Corlometer" and on "A New Form of Laboratory Apparatus." Mr Maximilian Toch read a second paper on "The Protection of Steel Against Corrosion," and Mr C. F. Carrier, Jr., spoke briefly on "Cheap Power from Steam" in connection with a sodium chloride electrolysis scheme, the exhaust steam being used for evaporation.

Wisconsin Section American Electrochemical Society.—At a meeting held on April 5 in the lecture room of the Chemical Engineering Building of the University of Wisconsin, at Madison, Mr. Carl Hambuechen lectured on "The Manufacture of Dry Batteries." The attendance was 50

Engineering Society of Wisconsin.—The engineers of Wisconsin have formed a State society with over 150 charter members. The first meeting was held at the University of Wisconsin from April 24 to 26. Among the papers presented was one by Prof. C. F. Burgess, who discussed the new problem of standard of gas and electric service. Professor Burgess has done important work in enabling the Wisconsin State Railroad Commission to prescribe a standard for fuel and illuminating gas.

Gauges.—The Bristol Company, of Waterbury, Conn., have issued an illustrated bulletin on their recording gauges for pressure and vacuum, and are about to issue a more extensive catalog on the same subject.

Swenson Evaporator.—The name of the corporation manufacturing the Swenson evaporator, leaching cells, diffusion batteries, heaters and other chemical machinery, has been changed from the American Foundry & Machinery Company to the Swenson Evaporator Company. The office will be as before, at 944 5-6 Monadnock Block, Chicago. The new company have retained the same organization and Mr. F M. de Beers, formerly manager of the American Foundry & Machinery Company, will continue in charge of the business.

Museum of Safety and Sanitation.—The executive committee of the Museum of Safety and Sanitation, 29 West Thirty-ninth Street, New York City, has detailed Dr. Wm. H. Tolman, the director, for field work. He will start on May 1 on a lecturing tour. Chambers of commerce, manufacturers' associations, engineering, insurance and architectural societies, railway and other clubs, may avail themselves of this illustrated exposition of devices and methods for the cost of the lantern operator ($10), if not too far removed from the itinerary.

*These are comparative figures for aluminium and copper:

	Aluminium.	Copper.
Density	2.68	8.93
Specific resistance	2.88×10^{-6}	1.8×10^{-6}
Tensile strength in kilograms per square millimeter	20.1	30.0
Linear coefficient of expansion	0.231×10^{-4}	0.18×10^{-4}

Digest of U. S. Patents

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC FURNACES (*Continued*).

No. 589,048, Aug. 31, 1897, Charles A Timme, of New York City, N. Y.

Resistance type This furnace is a rectangular muffle for dental use, capable of heating articles to a temperature of 3500 F. The muffle is a box of metal with a non-conducting lining, within which are removable heating-plates, formed of refractory material with an imbedded platinum resistance wire The top and bottom plates slide on flanges The temperature in the muffle may be varied by switching in one or more plates, or a portion only of one plate The front of the muffle is closed by a cover having a peep-hole.

No. 597,476, Jan. 18, 1898, Thomas L. Willson, of New York City, N. Y.

Arc type. This furnace, especially designed for the production of calcium carbide, is a brick-work structure containing two smelting chambers Each chamber may receive a cast-iron pot on wheels, serving as the lower electrode; or the chamber may have a fixed hearth consisting of a horizontal iron plate, and side walls of carbon. The upper electrode is a depending carbon block consisting of a number of plates, the upper ends of which are held in a metal clamp carried by an adjustable stem. This stem is square and passes through a square opening in the adjacent edges of hinged trap-doors above Hoppers deliver the charge-mixture through ports into the smelting chamber at each side of the depending electrode The iron pots have a horizontal rib at one side, which is gripped by a number of iron clamps individually connected to one set of electric conductors. The other set of flexible conductors is connected to several horizontal rods projecting from the stem of the upper electrode The calcium carbide gradually builds up in the bottom of the pot until it is filled. The pot is then wheeled out and replaced by an empty one, the carbide in the filled one being cooled and dumped Or the molten material may be tapped from the crucible or fixed hearth. Or the material may be allowed to solidify in the fixed hearth, the door opened, the loose material poked away and the pig of carbide pulled out by hooks The fumes from the chamber pass

through a settling-chamber containing a series of pockets, and thence escape to a stack.

No. 597,880. Jan. 25, 1898. William Smith Horry, of Sault Ste. Marie, Mich.

Arc type. This furnace, especially designed for the production of calcium carbide, comprises a rotating receptacle in a form of a wheel or annular trough mounted on a horizontal shaft. Carbon electrodes of opposite polarity are adjustably supported on the inclined walls of the feed-hopper opening into the annular trough at one side. The adjacent ends of the carbons are beveled to provide a vertical passage, between which the arc strikes, the charge being fed through it. As the wheel gradually rotates downward from the electrodes, the calcium carbide builds up and plates are bolted onto the trough to retain the carbide and unreduced materials surrounding it. The solidified carbide is removed from the back of the wheel, on the side opposite the electrodes, plates being successively removed from the trough at this point and portions of the carbide pig being broken off. The production of carbide is thus continuous, and the pig is of uniform quality throughout, whereas the carbide produced in non-continuous pot furnaces is poor at the bottom of the pig, rich in the middle, and again poor at the top. The old furnaces also waste much of the charge, the coke and the lime being caked together, but not smelted. The feed-hopper is lined with fire-clay and fire-brick and is pivoted to hang between the flanged sides of the trough. The wheel is slowly rotated by worm and pinion. The rate of rotation is controlled by the operator to maintain the electric current constant

NEW BOOKS.

The Miner's Pocketbook. By C. G. Warnford Lock. A reference book for engineers and others engaged in metalliferous mining. Fifth edition, entirely rewritten. 233 illustrations. 632 pages. Bound in leather. Price, $4 net. New York: Spon & Chamberlain.

The Gas Engine. By Cecil Percy Poole. 100 pages. Bound in cloth. Price, $1 net. New York: Hill Publishing Company.

Suction Gas Plants. By C. Alfred Smith. 55 illustrations. 7 + 198 pages. Bound in cloth. Price, $1.75 net. Philadelphia: Lippincott Company.

Working Hints for Suction-Gas Producers. By A. Flurcheim. 2 plates. 40 pages. 50 cents net. New York: Spon & Chamberlain.

An Introduction to the Science of Radioactivity. By C. W. Rafferty. 12 + 208 pages. Bound in cloth. Price, $1.25 net. New York: Longmans, Green & Company.

A Handbook of Electrical Testing. By H. R. Kempe. Seventh edition. Revised and enlarged. 385 illustrations. 714 pages. Bound in cloth. Price, $6. New York: Spon & Chamberlain.

Alternating Currents Simply Explained. By Alfred W. Marshall. An elementary handbook on alternating-current generators, transformers and motors. 90 pages. Paper binding. Price, 25 cents. New York: Spon & Chamberlain.

An Electric Furnace for Spectroscopic Investigations with Results for the Spectra of Titanium and Vanadium. By Arthur Scott King., Washington, D. C. Carnegie Institution of Washington, 1908 (1909). 15 pages. (Contributions from the Mt. Wilson Solar Observatory.)

Heat for Engineers. By C. R. Darling. A treatise on heat, with special regard to its practical applications. 442 pages. Bound in cloth. Price, $5. New York: Spon & Chamberlain. Reinforced concrete field handbook. By the editors of *Concrete Engineering* Allen Brett, Ed. 127 pages. Bound in cloth. Price $1. Cleveland: Technical Publishing Company.

Machine Drawing and Design for Beginners. An introductory work for the use of technical students. By H. J. Spooner. 266 pages. Bound in cloth. Price, $1.25. New York: Longmans, Green & Company.

Law and Business of Engineering and Contracting. By C. Evan Fowler. With numerous forms and blanks for practical use. 9 + 162 pages. Bound in cloth. Price, $1. New York: McGraw Publishing Company.

BOOK REVIEWS.

Some Electrochemical Centers. A Report to the Electors of the Gartside Scholarship. By J. N. Pring, M.Sc., Gartside Scholar; 138 pages. Retail price in New York, $1. Manchester: University Press.

It is a pleasure to call attention to this book. It is simply a report on electrochemical industries as they are or were a year or two ago. No attempt is made to discuss hypothetical questions of a scientific nature. But the discussion of the industrial problems is made from a broad viewpoint, both the technical and the economic sides being considered.

There are eleven chapters—short monographs on the following subjects: Cost of power production; Niagara Falls; the copper refineries of New Jersey; Canadian water power and electrochemical centers (including an account of the Betts process); electric smelting of iron ores and steel production; ozone and water purification; gold and silver refining; electrical manufacture of carbon bisulphide; electrochemical industries in the Alps, France and Belgium; the electrical fixation of atmospheric nitrogen; power centers and electrochemical works in Great Britain.

The report of the author is based on information acquired during visits to the United States, Canada and Continental Europe during 1907 and 1908. The author has evidently shown excellent judgment in collecting his information.

This is what the author says on the rapid strides made by the electrochemical industry in America: "Untrammelled by the existence at home of chemical works on a sufficiently extensive scale to provide the rapidly growing demands, the newer processes have here found a very suitable locality for their development, and during their infancy enjoy the fostering influence of a protective tariff. The progress in America is also due in no small measure to the great enterprise and superior technical training of the people."

A comprehensive handbook on industrial electrochemistry remains still to be written. The time is hardly yet ripe for that. But the reviewer says unhesitatingly that this Gartside report of Mr. Pring—though naturally somewhat sketchy in character—is the best all-around book on industrial electrochemistry that has so far come to his notice.

* * *

The Design and Equipment of Small Chemical Laboratories. By Richard K. Meade, B. S. 138 pages, illustrated. Price, $2. Chicago, Ill.: The Chemical Engineer Publishing Company.

This little book is written primarily for young chemists just out of the technical school or college, who have to design a chemical laboratory. The author states that this "often happens." Frankly, we should say that it happens only in a minority of cases.

The book has a wider scope, however, and cannot fail to be useful to the chemist of wider experience, for it contains much useful information and practical hints in a condensed form. In fact, the book could well be enlarged to suit the needs of the research chemist as well as the analytical chemist.

There are 14 chapters dealing with the following subjects: General arrangement; hoods; sinks and water supply; desks; table and apparatus for rapid filtration, etc.; ignition table and apparatus for ignitions; table and apparatus for filtrations; balance support, balance and accessories; heating appliances; preparation of distilled water; apparatus for electrochemical analysis; sampling appliances; assay furnace and accessories; miscellaneous laboratory equipment.

Electrochemical and Metallurgical Industry

VOL. VII. NEW YORK, JUNE, 1909 No. 6

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York
EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH.D.....*President*
E. F. ROEBER, PH.D.....*Editor and Secretary*
C. E. WHITTLESEY.....*Treasurer*

Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, JUNE, 1909.

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Niagara Falls Meeting of the American Electrochemical Society.

In its short career of seven years the American Electrochemical Society has held many highly successful meetings, but none more successful than the convention last month in Niagara Falls. The society was formed seven years ago at the right moment to become useful, and in its career the society has never missed the psychological moment when there was an opportunity to prove useful. A case in point was the symposium of papers on the electrometallurgy of iron and steel at the Niagara meeting. But the balance of the program was equally attractive. The result was a record-breaking attendance, not only at the convention in general, but in all the sessions devoted to the reading and discussion of papers. The esprit de corps which unites the congenial members of this society—though they be scientists or engineers, electrochemists or chemists or metallurgists or electrical engineers—was as dominant as ever, and the social functions were immensely enjoyed. Great credit is due to all Niagara Falls members who did so much for the success of the meeting, under the leadership of President Acheson.

* * *

But any words of appreciation, however brief, would be wholly incomplete without special mention of "Section Q." It was amusing enough when a speaker at the banquet in making announcements for the convention to be held 25 years hence at Niagara Falls attributed various activities to the Sections A, B, C . . . finally coming down to Q as the section devoted to the utilization and absorption of alcoholic solutions. But this was a little bit hard on Section Q after its record of the night before. Whatever may have been its primordial history, surely at its session held after the official smoker it proved that it has a mission to fulfill. In vino veritas. Nobody has any right to appoint himself a pronouncer of truths about others in a "holier-than-thou" attitude. But nobody would dream of such an attitude in Section Q, and if truths are told in such a kindly spirit of fun and in such a clever way as Section Q did with its cartoons of members and its experimental lectures, even thin-skinned dignity should not feel hurt. Cartoons of men are like integrals between certain limits. They are true, but between the assumed limits, and any scholar of modern physics understands that. The different cartoons, experimental lectures, and other features of this extravaganza session were by no means artistically equivalent, but they were all inspired with the same frolicsome merriment. Section Q was born, not made. It is the natural outcome of the peculiar congenial atmosphere that comes with every meeting of the Electrochemical Society. It is a symptom of perfect health. It acts as a safety valve. It is irrepressible. This is the raison d'être of Section Q.

The Symposium of Papers on the Electrometallurgy of Iron and Steel.

The symposium of papers on the use of the electric furnace in the iron and steel industry proved a great drawing card and proved also a great success. The whole of two sessions, or half the first day of the convention was thereby taken up. The program was logically divided into two parts, namely, the reduction of pig iron from ore, and secondly, the melting and refining of steel in the electric furnace. Under average conditions, in this and most other countries, the use of the electric furnace for pig iron reduction is mainly of theoretical interest. This was clearly indicated in the papers, as far as they recorded actual developments. In Norway, Canada, and California, where the intention is to use the electric furnace commercially for iron-ore reduction, there exist very special conditions, unfavorable to blast-furnace practice and favorable to electric-iron furnaces. The conditions in California were well sketched by Mr. Bennie, and the situation in Canada and Norway is in many respects similar. But the papers presented at the convention emphasized properly, with special stress, the furnace design. The problem in its general and economic aspects has been so often discussed that, as Dr. Haanel said, the one thing that remained to be done now was to design a proper furnace and run it continually for a proper length of time.

* * *

This has been done and is being done in Sweden and in California, and it is interesting to compare the two furnace designs. They have much in common, a high shaft being superposed in both designs upon a crucible containing the electrodes. Both furnaces employ tuyeres, but for different purposes. In the Swedish furnace, gaseous products of combustion taken off from the top of the furnace are blown back into the crucible for the purpose of cooling the arched roof above the electrodes. In the California furnace, air is blown in to burn the carbon monoxide to dioxide in the shaft above the descending charge and thus preheat the charge. Dr. Richards' paper considers in an interesting manner a combination of blast furnace and electric furnace; he really suggests to modify the ordinary blast furnace, so as to add in some way supplementary electric heat at the tuyeres in order to increase the economy of operation. In one of the papers the old suggestion of Dr. Héroult was mentioned to charge the iron ore and the reducing carbon separately into the furnace. In this case it would be possible to burn all the carbon to dioxide. But it seems that the practical difficulties have so far been unsurmountable.

* * *

Naturally of far greater practical importance and of more general interest were the papers on electric steel making and refining. Every type of electric steel furnace was discussed in these more papers, and the program was truly international. The personal presence of Major Stassano, of Italy, and of Mr. May, of England, gave a particular charm to the proceedings. The universal interest that the iron and steel industry takes in electric steel, was clearly indicated by the fact that every important steel concern of this country was represented by one or more representatives, who were evidently intensely interested, but remained silent spectators. This silence was golden. Nor was there any cross-examination of representatives of one type of electric-steel furnace by representatives of other types. This was surprising in view of the competition which exists. Although there was, therefore, no real general discussion, the program of papers was so excellent and well balanced as to give a very good view of the present situation in this new and rapidly growing industry. The American Electrochemical Society may be well satisfied with the success of this symposium. More than one of the practical steel men remarked privately that they had to come to this society to learn something new about their own profession.

* * *

Our report of the papers in this issue will be found so full that there is no necessity to discuss them here in detail. Only a few remarks may be made on the one paper, by Mr. Hibbard, in which a somewhat discouraging view was taken. To balance the program this paper was needed. A doubting Thomas in a crowd of enthusiasts is always useful. Mr. Hibbard's paper was suggestive and brought out good points. But this does not mean that we agree with the general view taken by Mr. Hibbard. He does not deny that the electric furnace can do certain things for steel, but he doubts whether the cost is worth the price. His argument is, for instance, that steel rails, if they cost more, should last longer; but that the manufacture of electric-steel rails is not yet old enough to permit a definite verdict. The best answer to the critical position assumed by Mr. Hibbard is the existence of over 60 electric-steel furnaces in commercial operation in different countries, and the fact that new furnaces are continually added. Though there would have been much justification in Mr. Hibbard's criticisms about a year or two ago, it seems to us they came now post festum.

* * *

One thing should not be overlooked in estimating the commercial prospects of the electric-steel furnace. It is the fact that its introduction does not mean the scrapping of existing metallurgical plants. The electric furnace is not a competitor, but a supplement to existing plants. We can speak even more strongly. The electric furnace not only does not mean scrapping of old plant, but it seems destined to prevent the scrapping of old plant, as it promises to give a new lease of life to the converter. The general tendency of recent years has been away from converter steel toward open-hearth steel, and pessimists have already seen the beginning of the end of the converter. It is at this point that the electric process steps in, since the combination of the converter with the electric furnace should satisfy all reasonable requirements. This fact and the undeniable tendency of the times to demand better steel for general purposes, are considerations of utmost importance, if it is questioned whether the cost of electric-steel refining is worth the price. We hope our report in this issue will prove interesting, instructive, and suggestive reading.

Heat Transmission and Heat Insulation.

The laws of heat transmission in steam boilers, sketched in Dr. Nicolson's paper in this issue, should not be without interest to metallurgical and chemical engineers. Effective heat transmission is all-important for furnaces heated from the outside, just as effective heat insulation is needed for other furnace problems. (As a strange anomaly it may be mentioned in

parenthesis that the same material—fire clay—is now generally employed for heat insulation in fire brick and for heat transmission in zinc retorts.) The point which is very strongly brought out in Dr. Nicolson's paper and which is too generally and too easily overlooked is that the thermal conductivity of the walls and the temperature of the charge inside and the temperature of the air or water outside do not alone determine the flow of heat through the walls. There may be, and as Dr. Nicolson shows for boilers there is, a very considerable sudden temperature drop right at the two surfaces of the walls, and this temperature drop depends on the speed with which the charge, air, etc., are moving along the walls. If these "contact resistances" to the flow of the heat are not taken into consideration, calculation of the heat flow is liable to lead to very erroneous results.

The Evolution of Furnace Design for the Fixation of Atmospheric Nitrogen.

The new process of the Badische Company for the fixation of atmospheric nitrogen is described in this issue in a very interesting paper by Dr Schoenherr. In electrical and mechanical respects this new electric arc furnace is of almost ideal simplicity and may be considered as the limit of a long series of trial designs. First the endeavor was to subdivide the electric discharge into as many small discharges as possible: this was the era of the spark furnace, as exemplified by the historical Bradley-Lovejoy furnace. Then the necessity became manifest to simplify the construction and to use larger units, and inventors gave up the spark furnace for the arc furnace. This meant a great simplification, and the Birkeland-Eyde furnace with its arc disk, produced by exposing the arc to an alternating magnetic field, became the first commercial apparatus, in which the fixation of atmospheric nitrogen by electric discharges through air became a commercial success. It is a large unit and a comparatively simple apparatus, but the necessity of having a big electromagnet involves a certain clumsiness. Compared with this, the furnace of the Badische Company is of still greater simplicity. It consists of nothing but a number of coaxial iron tubes, with a water-cooled top and an iron electrode in the bottom. From an electrical standpoint, the possibility of producing a quiet alternating-current arc of some 5 m or 7 m length (16 ft. to 22 ft.) is most surprising, and the method of producing this quite long arc by means of a helical air current (which is thereby changed into a gas mixture containing nitrogen oxides) is as simple as ingenious. It is hardly possible to imagine anything simpler electrically or mechanically, and Dr. Schoenherr must be sincerely congratulated on the success of this work.

* * *

Nevertheless, Dr. Schoenherr's paper will be found disappointing in one important respect. It is interesting enough to learn that the new furnace is superior to the Birkeland Eyde furnace not only in giving a higher efficiency (that is, more nitric oxide per kw-hour), but also a more concentrated gas mixture (that is, more nitric oxide per cubic foot or per pound of gas mixture). The first point is important for the economy of power utilization, the second point for the economy of the subsequent transformation of the gas mixture into nitrite or nitrate or nitric acid. But why not give exact figures, as the Birkeland-Eyde people have done? Only on the basis of exact figures it will be possible to judge whether the process has outgrown the peculiar conditions of the country of its commercial birth—Norway—with its exceedingly cheap power. It almost seems so, since it is reported that the Badische Company intends to use the Alz water-power in Germany for operating the process. For the present, however, we can only repeat what we have said more than once before, that the success of such processes in Norway—with a cost of the electric hp year somewhere between $4 and $8—is no criterion whatever for forming an estimate on the possibility of commercial success in this country.

Leaching Processes in General.

So many instances of wet processes, or rather proposed wet processes, occur either as disclosed by the records of the Patent Office or by the reports published in the technical press of experiments, that a few general remarks about the difficulties of hydro-metallurgy are not at all superfluous. The field is very attractive. It is apparently a simple matter to treat an ore with a chemical and extract its value thereby. But the meager results from the vast amount of experimental work done do not justify the first impressions that are given to the casual observer. Possibly because the first experimental work can be done so very cheaply in the ordinary analytical laboratory and its allurements are so many, there will always be much experimental metallurgical work in the wet way.

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Metallurgical processes can be divided into two classes: first, those that work on ores and, second, those that work on crude metallurgical products, such as matte or impure bullion. Wet processes of the second class have had a considerable degree of success. For example, the electrolytic refining of "converter" copper, "base" lead bullion, Doré silver bullion, are each hydro-metallurgical processes that not only compete with pyro-metallurgical processes but have in some instances entirely superseded them. Wet processes of the first class—that is, working on the ore or concentrate direct, have in only two cases decided superiority over smelting processes. These two are the cyanide process for gold ores and the leaching of bauxite by caustic soda for the production of alumina to be used in the electric decomposition cell. We would hardly call the amalgamation of gold ores by mercury a wet process, as the ore is not leached at all. The other processes that come in this category, but are of minor importance, are the chlorination of gold ore, the hyposulphite lixiviation of silver ore, and the "patio" process likewise used on silver ore. The last is used largely on Cripple Creek gold ores and the latter two chiefly on Mexican silver ores, when a silver mine is remote from smelting centers. The leaching of copper ores by weathering is practiced largely by the Rio Tinto Company in Spain. The precipitation of copper bearing mine water at Butte is of some importance. But in examining all the above mentioned cases, it can be readily seen that of all existing processes the cyanide process alone is of supreme industrial world. This is due to the inherent advantages of a low cost solvent that attacks chiefly the valuable constituent of the ore rather than its common mineral impurities, to a cheap and effective precipitant, and to the fact that it operates well on crushed rail-

ings from another cheap process—the amalgamation process.

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The hydrometallurgic processes for silicious oxidized copper ores and also for complex lead-zinc ores, especially when combined with electrolytic deposition, are apparently attractive. But while their name is legion, their practical or commercial success is little. Of all the countless proposals for leaching copper ores we can count only on two in this country that have any degree of importance. And there are no successful lead-zinc wet processes, though the field for them is wide, because of the millions of dollars of zinc wasted each year by the lead smelters of this country.

* *

The reason for all this is obvious to the competent metallurgical engineer. Leaching experiments on a small scale give rarely any criterion of results to be expected on a large scale. And also the amount of power for the electrolytic deposition of one ton of metal out of a weak solution against an insoluble anode is large. So the cost of deposition is high and the capital outlay for power house and vat house enormous. Besides there are many possible and unexpected impurities in the ores that are soluble or at least partially so in the different reagents used and quickly foul the solution. Thus, as Mr. D. H. Browne says, the initially good chemical condition cannot be cheaply maintained. In short, there are many basic reasons why wet processes for base metal ores die in the borning. If we compare them with methods using the reverboratory furnace or the blast furnace, with the addition of the proper fluxes, we see that we have in the heat treatment the chance to increase the temperature, or to change the charge, and that these changes enable the reaction to proceed easily. In a wet process it is usually a question of one or two new reactions and three or four mechanical processes to regenerate the solution, when a new impurity is formed. The pyro-metallurgical process is simple and powerful. The hydro-metallurgical process is complex and weak.

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It is to be doubted if the cyanide process in the Rand could compete with copper smelting and recovery of the gold in the electrolytic refining, were it near a large copper camp with plenty of ferruginous copper ores and with a cheap coke supply. The result would be the same as at Cripple Creek. The blast furnace takes what ore it wants and the leaching plants have what is left. We do not wish to discourage any inventor of a wet process, for probably they have already discouragements enough. But it is well to look the facts in the face. Any wet process can only succeed in its peculiar niche where its inherent advantages outweigh its inherent disadvantages. In a wet process the motto "tout bien ou rien" must apply. In short, a new wet process must resemble in neatness and effectiveness the cyaniding of gold or silver ore or it need not "apply at the gate."

Mining Accounts.

We have printed out several times in these columns the fact that in computing mining costs quite often little attention is paid to the cost of development and exploration, and that while the actual breaking of ore in the stopes is usually a cheap process yet it forms only a small proportion of the total cost. The largest and most variable factor is the finding of the ore and the amortization of the requisite plant to put the ore in commercial form. These often triple the cost of mining pure and simple. With modern corporate finance, an accurate system of accounts and publicity are now demanded of corporations by the investing public. In fact, it is a healthy sign of the times that this is better realized each year. And mining companies should be no exception to the rule.

* * *

Mining accounts are, of course, most difficult to reduce to a logical system of distribution of costs, because the amount of ore to be extracted during the life of the mine as well as the costs of extracting the ore, and the profits therefrom, is dependent on many various and uncertain factors. In this it resembles the accounting of experimental work. Nevertheless, the subject is being attacked nowadays in a more proper manner than heretofore. This country can learn much from England in this respect. There, the methods of the high-class companies engaged in financing and developing mining properties are conservative, yet conservative with a conservatism well-tinctured with engineering optimism. The result is that mining is on the whole on a more satisfactory and business-like basis, and wild-cat concerns are much less in evidence in England than in this country. There, the risk is eliminated, or rather the risk is reduced to known terms. And by engaging in a number of enterprises where the average chance for profit outweighs the average risk, probability greatly favors success.

* * *

Naturally, in almost every mine a large amount of money must be spent in finding the ore and this expenditure must be amortized by the company to enable the company to get first a new dollar for an old one. After the cost of development has been met the profits are to be recorded. The time allowed for amortizing the exhaustion of the ore in the mine depends on geological and commercial conditions. This is a matter of technical and business judgment in estimating the life of the mine. In any event, it should be noted that once a mine is developed, the proper policy generally should be to mine the ore as rapidly as possible, for the interest charges on the value of the ore in the ground are a proper charge against the absolute cost of production.

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In an investigation of any kind, it is often well to take a case where the point to be investigated is seen in exaggerated form. In considering the question of proper charges for new exploration of the mineral veins, the records of any of the large companies operating in the Temiskaming silver district are suggestive. Here the cost of producing a ton of silver ore—for the ore of the "Cobalt" camp is, commercially considered, a silver ore—shows itself to be very high, for the veins are exceedingly narrow. Indeed, veins less than 2 in. wide are often worked there at a profit. This high cost per ton of ore is compensated for by the phenomenal richness of the ore. A vein 2 in. wide assaying 2000 oz. in silver is better than a vein 200 in. wide assaying 20 oz. One of the strongest of the companies operating in this district produced for the year 1908 approximately 3505 tons of ore which averaged 826 oz. of silver. The cost of production of the sorted ore totaled, in round numbers, $361,000, an average of $105. The cost of the actual

"stoping" the ore was but $16.22 per ton, and the sorting out of the ore was $5.90 per ton. Thus the actual mining operation and sorting cost only 21 per cent of the total. Diamond drilling, surface trenching and underground development cost $52.91 per ton of product, or 50 per cent of total cost. The remaining costs of $30 covered such items as assaying, engineering, insurance, taxes and general expense. Summarizing the three items of finding the ore, mining the ore, and overhead charges, it will be seen that their respective proportion was, respectively, 50 per cent, 21 per cent and 29 per cent of the total cost. Marketing the ore was included under a separate schedule, but here, too, a conservative course was taken, and smelter deductions for losses in treatment and smelter tolls were charged against the production of an ounce of silver, the total cost being 20.7 cents per ounce of silver mined.

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Looking into the above, we can see that the ore could have been produced very cheaply, had no development work been done. Indeed, practically half the expense charged against the mining was laid out in finding new ore. If the amount of new ore found by this exceeded the ore extracted, the operation was profitably done. And with a proper knowledge of geological conditions this was attained. Hence, the great importance of engineering and managing ability is seen. Accordingly, it can be laid down as a fact that the costs of any mining company, producing rich ore or low-grade ore, should be analyzed by the interested parties and special attention should be paid to the amount of new work done, and the results obtained from this expenditure. When complete reports are made and the accounting is accurate and honest, mining finance will have less of the aroma of the racing stable about it than it has at present. Finally, let it be said that while mines die as individual men die, a mining company should live as a family lives. For when one mine is being exhausted, another mine ought to be found to take its place. When such a course is honestly and intelligently pursued, the financial returns are most attractive.

"Problems of To-Day."

The growth of the iron and steel business has depended in the past on the existence of high-grade raw materials, pure coking coals and rich Bessemer ores. These items of national mineral wealth were, when collected together, in the major part *raison d'être* of the United States Steel Corporation. Mr. Carnegie in taking, in exchange for his steel plants, a first mortgage on this real estate made security doubly secure. For a steel works will depreciate with the advance in the art, whereas raw materials of the first grade appreciate with the growth of business. Mr Carnegie has ever seen clearly the broad principles of political economy. And he has applied them to his business practically. In his latest book, "Problems of To-Day," he has enunciated several broad principles of social science. As he was both practical and theoretical in the conduct of business, all of his views on the questions of national life deserve respect and attention. Especially to the point is his critique on "Socialism." It is sane, common-sense like, and expressive of the highest side of individualistic humanitarianism. Substitute for crass and ignorant selfishness an enlightened self-interest and you have a state regenerated. Naturally, the words of the head of the firm of "forty partners" are most eloquent on the subject of partnership and profit-sharing. Mr. Carnegie gained his great wealth not by most careful attention to details—that was left to the partners—but chiefly by the use of a projected imagination. He applied to the practice of his business the several theories of his great countryman, Adam Smith. He may be criticized in many ways—for who may not be?—but considered in its entirety, his career is typical of the best of the American multimillionaires.

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The same care that was used in making his money work efficiently in business is now used in his philanthropy. He uses the same practical manner of making the money when passing out of his hands do the maximum that he did when he let Captain Jones built his "giant mixer." Consider the Carnegie system of libraries. In the first place, his libraries give pleasure and instruction to the multitude throughout the continent. But we opine his thought not this so much as to develop the exceptional youngster—the original mind amid thousands—which mind having the clear sight and independence of genius needs only the chance to read the philosophy of the ages, to make up his own philosophy applicable to the present. This, we believe, is due to Mr. Carnegie's sympathy for minds like his own.

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We can further adduce the Carnegie Institute where pure scientific research directed along commercial channels—the words are not paradoxical—has already helped much metallurgy, medicine, and general technology. This was also wise and efficient giving. Mr. Carnegie's donation to the United Engineering Societies with the Engineer's Club adjoining is a sane way to bind the professions together for the common good. Possibly the greatest gift, measured in direct benefits to the higher and intellectual side of American life, was the Carnegie Foundation for the pensioning of college professors. This has had two distinct spheres of influence. In the first place, the annual report gives many data concerning the academic life here and abroad and lays down the abstract laws of higher education in this country as based on the facts. The second result is to assure a body of men, whose whole life is in the ideal, of the fact that they will not suffer materially in their old age. Thus the dignity and standing of the college professor is raised. Also its attraction to the young as a career is increased. Moreover, it allows the professor the leisure at the end of a long life a chance to produce his "magnum opus." This opportunity has been taken advantage of in one instance already, and a notable addition to Shakespearana is a concrete result. We think this is obtaining the maximum of national good at a minimum of expense.

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We may be open to the charge of unduly praising Andrew Carnegie, but a man's work is, indeed, above himself, and judging by results, we believe that he practices what he preaches. We see ever the same rare intellect in obtaining a maximum of return, be it in absorbing dollars or in distributing dollars for the benefit of the social organism. The attempt to attain the maximum of efficiency to make the best of the best that there is in life, is the problem of the twentieth century. Has any one attacked it more intelligently than Andrew Carnegie?

Summer Meeting of the American Chemical Society

The Summer meeting of the American Chemical Society will be held in Detroit, Mich., from June 29 to July 2 inclusive. On the previous day a business meeting of the council will be held. The meetings of the sections and divisions will be held on Tuesday and Wednesday, June 29 and 30, and on Friday, July 2, in the Central High School, which has ample facilities.

On Tuesday evening a complimentary smoker will be given by the Society of Detroit Chemists to the members of the American Chemical Society.

On Wednesday afternoon the members will inspect the works of Parke, Davis & Company, to be followed by a lunch and a moonlight boat ride on the Detroit River, complimentary to the visiting chemists from this firm.

On Thursday the members will take special cars to the University of Michigan at Ann Arbor, where they will be the guests of the University of Michigan for the day, returning to Detroit in the evening for the usual banquet. The program will be continued on Thursday at the University of Michigan and will consist mainly of special papers of wide general interest.

On Friday the sectional and divisional programs will be continued and excursions taken to manufacturing plants in Detroit.

The headquarters for the meeting will be at the Hotel Pontchartrain. Details in regard to this hotel and other hotels in Detroit may be obtained by addressing the secretary. It is suggested by the local committee that it is very necessary to make hotel reservations in advance, as Detroit is liable to be crowded at this time.

Special arrangement is being made for the entertainment of ladies who accompany members.

New York Meeting, American Institute of Chemical Engineers.

The first semi-annual meeting of the American Institute of Chemical Engineers will be held in New York City from June 24 to June 26.

The first day, Thursday, June 24, will be devoted to the reading and discussion of papers; the session to be held at the Polytechnic Institute, in Brooklyn.

The following papers have been announced:

"The Utilization of Low-Grade Fuels in the United States," by O. K. Zwingsenberger.

"Creosote Oil from Coal-Gas Tar," by Dr. S. P. Sadtler.

"Automatic Acid Egg," by Richard K. Meade.

"Some Experiments on Case-Hardening of Steel with Gases," by Dr. J. C. Olsen.

"New York Metropolitan District as a Center for Great Industries," by Dr. C. F. McKenna.

"Methods of Clay Control," by J. G. Dean.

A number of additional papers will be presented during this session, of which the exact titles have not yet been announced.

For Friday and Saturday a number of very interesting excursions have been arranged. It is understood that chemical engineers engaged in similar work will not attend these excursions unless the same courtesy of inspection is extended from their own plants.

The excursion for Friday, June 25, is as follows:

9.00 a. m.—Excursion to the Atlantic White Lead & Linseed Oil Works (foot of Gold Street, Brooklyn, N. Y. (Manufacture of white lead, boiled linseed oil, lead pipe and sheet lead.)

1.30 p. m.—The National Lead Company's steam lighter will convey the members of the institute and their guests to the Hudson. Lunch will be served on the lighter.

Excursion through the Edgewater plant of the Corn Products Refining Company. (The manufacture of glucose, starch and by-products.)

Excursion through the plant of the Warner Sugar Refining Company, at Edgewater. The return trip will be made on the steam lighter *Atlantic*, and a subscription dinner will be held in the evening.

The program for Saturday includes an excursion to the Standard Oil Company's plant at Bay Way, N. J. (refining oil and by-products). Various points of interest in and around New York will also be open for inspection, among them the Brooklyn Navy Yard, the Hudson & Manhattan Tunnel plant, the plant of the Consolidated Gas Company at Astoria, L. I., the Manhattan Bridge (now nearing completion), the Pennsylvania Railroad tunnels and improvements, the DeForest wireless telegraph installation in the tower of the Metropolitan Life Building, etc.

The hotel headquarters will be at the Hotel St. George in Brooklyn. Dr. J. C. Olsen, of the Polytechnic Institute, in Brooklyn, is the secretary of the American Institute of Chemical Engineers.

The Iron and Steel Market.

A distinct upward trend in iron and steel prices manifested itself in May, the natural sequel to the radical reductions involved in the abandonment of the price maintenance policy in February and the increase in buying during March and April. Bars, plates and shapes advanced a dollar a ton about May 10, following a like advance in the closing days of April, and the market thus became established on the basis of $1.20 for bars and $1.30 for plates and shapes. These are the prices made immediately after the market was declared open Feb. 18 last, there having been a further decline of $2 or more a ton thereafter.

Wire products were reduced May 1, by $7 a ton on wire nails, $8 on plain wire and $10 on barb wire. The reduction had long been anticipated, being a part of the general reduction involved in the adoption of the open market policy. It was delayed because the spring business in wire was well under way. The reduced prices of May 1 were $1.40 on plain wire, $1.60 on nails, $1.60 on painted barb wire and $1.90 on galvanized barb wire. The cut was made a deep one in order to stimulate buying, and the move was an entire success. The mills accepted orders only for early shipment, practically as early as they could make, and in a fortnight had booked all the business they wished at the extreme prices, an advance of $2 a ton being accordingly announced, effective at the close of business, May 15.

Early in May an advance was made by the steel interests in light rails, the heavier sections being advanced about $4 a ton and the lighter sections $5 to $6. The rerolling mills had practically given up the competition.

While technically May showed a decline in wire products, the reduction was a delayed one, while the advance was in keeping with the trend of the market. Thus it may be said that in May bars, plates, shapes, light rails and wire have been advanced. These lines comprise between 55 and 60 per cent of the entire finished steel output, but it must be remembered that the price of standard rails was not brought in question. The decision to throw the market open in February distinctly excluded rails. They were not reduced and therefore could not be advanced, and as they constitute about 20 per cent of the total output, the lines which were advanced in May constitute between 70 and 75 per cent of the finished steel products, the price of which has been in question.

The advances made are therefore important, but they must be taken in their bearing. They merely remove the extreme of the reductions, and leave prices very low in comparison with prices ruling in 1907.

One important reason why these advances were made was that buyers were disposed to contract more freely than suited the purpose of the mills; the rate of buying was quite in excess of the rate of consumption, and some purchases were largely of a speculative character. It was desired to discourage such buying, and to sell material only in proportion as it was being consumed.

The tone of the steel market has passed from extreme pessimism to extreme optimism, and extreme views are usually erroneous. It is obvious that such is the case in this instance. The February price break occurred in a month when pig-iron production was at the greatest rate recorded since October, 1907, about 22,500,000 tons a year, while in April production declined to a rate of 21,400,000 tons a year, and May production is not likely to have attained the February rate. It is improbable that buying in the next two or three months will be nearly as heavy as it has been in April and May, nor is it likely that production, despite the good buying that has occurred, will greatly increase.

The railroads have not participated in the general buying to the usual extent. It is estimated that they have been buying less than half as much as in 1906 and 1907, and it is fair to estimate that in those years they took 40 per cent of the entire iron and steel output. The 1906 pig-iron production was 25,300,000 tons, and the 1907 production, had it not been for the slump in the two closing months of the year, would have been about 27,300,000 tons. The mean of these is 26,300,000 tons. Allowing the railroads 40 per cent of this and estimating that their purchases have declined 50 per cent., the loss is 5,260,000 tons, deducting which leaves 21,000,000 tons. Now the fact is that pig-iron production from Jan. 1 to May 1 was at the rate of about 21,700,000 tons. This is somewhat startling. It would hardly be assumed that buyers other than railroads have been taking a larger tonnage than in 1906-7. They have probably taken nearly as much, while there has been some accumulation of material. This should preclude any great increase in production. It is known that in many cases jobbers and manufacturers have been replenishing stocks, under the stimulus of very low prices, and the next gain to the steel trade must be through an actual and large increase in ultimate consumption. There is no prospect that the railroads will largely increase their purchases.

Pig Iron.

The pig-iron market has shared the optimism prevailing in the finished steel trade. Prices have been advanced sharply in the central West, and moderately in Virginia and the East. Sales have been fairly large. Eastern steel works have bought 80,000 tons or more of basic, chiefly for third-quarter delivery, while central Western steel works have bought probably half this tonnage, and they have taken also about 25,000 tons of Bessemer. The central Western sales, particularly of Bessemer, have been chiefly for May and June delivery, and the market has advanced sharply. Bessemer iron, quoted at $14.75, valley, or $15.65 Pittsburgh, in April, declined to $14.50, valley, several sales of 500 tons and less being made at this price. The buying started, about the 20th of the month, with a lot of 10,000 tons of prompt at $14.50 and within a few days the market had advanced to a minimum of $15, valley, or prompt, with $15.25 to $15.50 demanded for third quarter. Basic is about $14.50, valley, for prompt and third quarter and foundry and malleable about $14.75, valley. The Southern market remains at $11.50, Birmingham, for third quarter, but the $11 prompt iron does not seem to have entirely disappeared.

Billets and Sheet Bars.

The market is firm, but transactions are light, as consumers are well covered by term contracts, on which deliveries have improved. Billets are $23, Pittsburgh; $24.50, Philadelphia, and $24, Chicago, forging billets being $2 higher. Rods were $29 for Bessemer and $30 for basic open-hearth at the close of April. With the sharp reduction in wire products May 1 a regular reduction of $2 was made in rods, but mills indulged in sharp competition and sold some large tonnages at $1 to $2 less than the open market. With the advance of May 15 in wire products rod prices were advanced to $29 for Bessemer and $30 for basic open-hearth, at which figures the market is firm.

Finished steel prices, f. o. b. Pittsburgh, are as follows:

Steel bars, $1.20, base.

Iron bars, $1.30, base.

Plates and shapes, $1.30 basis.

Plain wire, $1.50, base; wire nails, $1.70, base; painted barb wire, $1.70; galvanized barb wire, $2.

Standard rails, $28; light rails, 40-lb. and 45-lb. sections, $26, in carload lots.

Sheets, 28 gage, black, $2.25; galvanized, $3.25; on attractive orders, 5 cents per 100 lb. less.

Tin plates, $3.40 for 100-lb. cokes.

Merchant steel pipe, ¾ in. to 6 in. inclusive, nominally 80 off in "jobbers' carloads"; actual inside price, 81 and 5 off.

Adoption of the Heroult Furnace by the Aug. Thyssen Company in Germany.

The "Deutscher Kaiser" Steel Works and the Mülheim Steel Works, owned by the August Thyssen Company, the largest German steel and steel-rail works, have closed a contract with the German owners of the Héroult patents.

Two large Héroult electric furnaces will be installed at the Deutscher Kaiser Works to purify and refine steel for rails from Thomas converters. Another furnace will be installed at the Mülheim works, and additional Héroult furnaces are to be constructed as soon as the foregoing are in operation.

In Memoriam—Henry August Hunicke.

On Monday, April 5, 1909, Henry August Hunicke died in the prime of his life in St. Louis.

Mr. Hunicke was born in St. Louis, Sept. 21, 1861. He graduated from Washington University in 1882 as engineer of mines. He then went to Germany to study at the Institute of Technology of Dresden, devoting himself especially to technical chemistry and gas analysis under Hempel. After a sojourn

HENRY AUGUST HUNICKE.

of somewhat over a year in Europe, spent in travel and study, a period rich in observation, and to which he always referred with the keenest pleasure in after life, he returned to the United States and entered the chemical laboratory of the Bessemer Steel Works at Wheeling, W. Va.

But he soon came back to his native city, St. Louis, where he took charge of the analytical and assaying laboratories of the St. Louis Sampling and Testing Works, which had been established by Professors H. A. Wheeler and Wm. B. Potter.

After having been interested for some time in a new process of zinc melting, which did not lead to lasting results, he be-

1894, adjunct professor of applied chemistry at Washington University, a position which he held until 1898.

He then became chemist to the Anheuser-Busch Brewing Association. In this position he found a field of greatest and widest activity. For instance, his investigation of the methods employed in the boiler house of the brewery and the recommendations that he subsequently made, rendered possible the saving of nearly $10,000 in the annual fuel bill. In the interest of Mr. Adolphus Busch he also began to pay special attention to the rubber industry and the manufacture of synthetic rubber.

In 1908 Mr. Hunicke severed his position with the Anheuser-Busch Company and established himself as independent consulting chemist and chemical engineer in St. Louis.

Mr. Hunicke was a member of the American Institute of Mining Engineers, of the American Chemical Society, of the Society of Chemical Industry, the Deutsche Chemische Gesellschaft, and the St. Louis Academy of Science. He was always active and willing to help when he saw an opportunity to promote science. He has been a very good friend of this journal. He was one of the founders of the St. Louis Chemical Society in 1903 and of the American Institute of Chemical Engineers in 1908. In the Institute he took great pride and he expected great results from its formation; he was a vice-president and the editor of the journal of the Institute at the time of his death.

American Foundrymen's Association Meeting.

The 14th annual meeting of the American Foundrymen's Association was held in Cincinnati, Ohio, beginning on May 18. In spite of the period of depression in the foundry industry the attendance was exceedingly good, being well above 2000. The regular exhibition of foundry machinery and appliances stimulates, of course a large attendance, and this year's exhibition, in charge of the Foundry & Manufacturers' Supply Association, was certainly very interesting.

From the report of the secretary, Dr. Richard Moldenke, we quote the following interesting points:

"Probably two lines of foundry economy have been more or less studied during the last year. They are the permanent mold, with the elimination of waste where success has been obtained, and continuous melting with the resulting increase in the output of existing plant units.

"The correspondence passing through the secretary's office has reflected the above mentioned tendencies rather sharply, and would seem to indicate that before long we will find foundrymen understanding their cupolas better and manipulating them to suit floor conditions, instead of vice versa. The permanent mold will probably still further special in the foundry, gradually drawing from the general trade certain castings, which have to be made very cheap and in quantity. Separate plants of comparatively small size, but enormous capacity, fully equipped to do just one line of work, turning scrap into finished castings of uniform composition and specified service requirements, will be located where the proper commercial conditions obtain and another chapter will be added to the growing volume on modern foundry practice."

An extended discussion on continuous melting resulted from the paper of Mr. S. D. Sleeth, on continuous melting in the foundry of the Westinghouse Air Brake Company. He gave an interesting account of their experience at Wilmerding, Pa. He summed up his experience in the advice: "See that the coke bed is burning even all around, then charge just as you would for an ordinary run, allowing an extra amount of coke for the dinner hour. After running about one hour, open the slaghole and keep it open, except during the dinner hour. Use about 40 to 50 lb. of limestone to 1 ton of molten metal; better use too much than too little. Have the cupola shell large enough, as it is easy to put in an extra lining for smaller heats."

To make continuous melting and pouring economical, Mr. Sleeth thinks the daily amount of work of the foundry should be at least 40 or 50 tons. The economies of the system, he explained, consist in getting back the sand in 20 minutes after the castings are taken out, in getting back the flasks promptly, and in the repeated use of sand and flasks on the same conveyor.

The other prominent feature of the convention, a discussion on permanent molds, was introduced by an excellent paper by Mr. Edgar A. Custer, president of the Tacony Iron Company, of Philadelphia.

Other papers presented at the meeting were by Mr. J. S. Whitehouse, of the Bonney-Floyd Company, of Columbus, on the side-blow converter for steel castings; by Mr. W. M. Carr, on the design of a small open-hearth furnace (500 lb. to 2-ton); by Mr. R. K. Meade on pulverized coal for foundry purposes; by Prof. B. Stoughton, of New York, on the cost of steel castings; by Prof. John J. Porter, of the University of Chicago, on chemical standards for iron castings.

Before the American Brass Founders' Association, the secretary, Mr. W. M. Corse, discussed the red brass ingot and the improvements in its manufacture that have led to its extensive use in castings from which a few years ago it was debarred. Mr. F. W. Reidenbach, of the Genesee Metal Company, of Rochester, N. Y., discussed the possibilities of utilizing the waste heat in foundries. At the works of the Genesee Metal Company a steam heating plant is maintained which heats the company's offices with the waste heat of only two No. 200 crucible furnaces; this represents an annual saving of $300 in fuel.

Mr. C. H. Wilson, of the Wilson Maeulen Company, of New York, pointed out that, while all steel men now recognize the great importance of pyrometers, brass founders have shown little interest so far to their own disadvantage. There is, however, still one difficulty to be solved in the use of electric resistance or thermo-electric pyrometers in brass foundries; that is the construction of a protecting tube which can be put in molten brass many times without frequent repairs or renewals.

Mr. Charles T. Bragg presented a paper on brass melting, Mr. E. H. McVeen on melting brass turnings in the oil furnace, Dr. W. D. Bancroft on the tensile strength of aluminium-zinc alloys.

Mr. Arthur T. Waterfall is the new president of the American Foundrymen's Association; Mr. William R. Webster, of the Brass Founders' Association; Mr. Eugene W. Smith of the Associated Foundry Foremen, and Mr. F. N. Perkins of the Foundry Supply Association.

The 1910 convention will be held in Detroit.

CORRESPONDENCE

Berthelot Monument.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—On March 25, 1907, Marcelin Berthelot, the great French chemist, and his wife were given a national funeral and accorded sepulture in the Pantheon.

It is now proposed to erect a monument to his memory by international subscription. M. Emile Loubet, former President of the Republic, was president of the committee of organization and now M. Armand Fallières, President of the Republic, is president of the committee of honor.

It would be but a just and opportune recognition of Berthelot's services to science in general and to electrochemistry in particular if American investigators shared in this worthy movement.

Subscriptions should be forwarded to M. Charles Goudchaux, treasurer of the committee, 16 Rue de Miromesnil, Paris, 8e, France.

Subscribers of 10 francs and over will receive a special copy of the "Livre d'Or de Berthelot," which will be published later.

NEW YORK CITY. CHARLES A. DOREMUS.

The Process of the Badische Company for the Fixation of Atmospheric Nitrogen.

In a recent paper before the Berlin Electrical Society Dr. SCHOENHERR gave an interesting review of the researches which have been carried out by him in conjunction with Mr. Hessberger since the end of the nineties, for the Badische Anilin und Soda Fabrik in Ludwigshafen, Germany. The complete paper of Dr. Schoenherr has now been printed in *Elektrotechnische Zeitschrift* of April 22 and 29. The following account contains all essential technical details:

In 1905 they succeeded in inventing a new electric furnace for combining the oxygen and nitrogen in atmospheric air by means of an arc discharge. The characteristic feature of their furnace is the use of a long, absolutely quiet, and stable arc. In their early experiments they became convinced that it is absolutely impossible to pass any large quantities of air through an arc in a direction perpendicular to the plane of the arc (though this has been the endeavor of many inventors). In all such experiments only a small portion of the air is subjected to the effect of the electric discharge and the resulting gases are therefore very dilute with respect to nitrogen oxide.

Higher concentrations of nitrogen oxide in the gases are obtained, however, if the air is passed along the surface of a quiet arc, although this is more easily said than done. An open arc of great length is exceedingly unstable and is liable to be extinguished at any moment, even if one imagines to have avoided the least bit of an air current. But to get a good energy efficiency it is necessary to bring large quantities of air in contact with the arc, and, therefore, to use a high speed of the air current. That means that the arc will be continually in danger of being extinguished.

The alternating-current arc is in any event of a very unstable nature, while a direct-current arc is much easier to be maintained. Under the present conditions of electric engineering, however, alternating current must be applied. These considerations indicate difficulties which seemed almost unsurmountable, but which have been overcome in a very simple way. *If the air is passed in a helical path around the arc the alternating-current arc loses its unstable character and becomes as quiet as a candle; it is then possible to include it within a rather narrow metallic tube without running the risk that the arc gets in contact with the walls of this tube.* The Badische Company now uses exclusively arcs within the center of a helical air current.

The apparatus is very simple. It is only necessary to arrange an electrode in the interior of a vertical tube near the bottom, but insulated from it, and to pass air through the tube in a helical path upwards, and then light the arc in some way. The simplest method of lighting the arc is as follows: The space between the insulated electrode and the walls of the tube is made very narrow at one point so that a spark will pass over on open circuit under the influence of the impressed potential difference. As soon as this happens the air current drives the one end of the originally very short arc upwards along the walls of the tube. The arc thus gradually becomes longer and longer, burning within the center of the tube. Its upper end is at a considerable distance above the insulated electrode at the lower end. At the upper end the gases are so hot that they have sufficiently high conductivity to permit the passage of an electric charge through them.

Since the arc is always used in series with an inductance coil, the voltage drops during the burning of the arc by such an amount that no new discharge can occur at the narrow space at the bottom where the arc was originally lighted.

Fig. 1 shows diagrammatically the form of furnaces now being used by the Badische Company. It consists essentially of a number of concentric vertical iron tubes, one within the other. The electrode at the bottom is an iron rod E, adjustable within a water-cooled copper cylinder. Only the iron rod is consumed. Under the influence of the heat of the arc the iron becomes coated with an oxide layer which evaporates slowly; according to the progress of the evaporation, the iron rod is pushed upwards. The electrode consumption is almost of no importance as an expense, the cost is only a few pfennigs per kw-year. The electrode rods used last about 2000 hours or three months. A new rod is inserted by screwing it to the old one; this takes not more than 15 minutes.

The water-cooled copper cylinder surrounding the iron rod is sufficiently removed from the surrounding iron tube so that there is no danger of an arc passing over. To start the arc the artificial electrode Z is provided which can be brought in contact with the electrode E. On removal, the arc starts and travels upward as described. The upper end of the arc always travels around within the water-cooled upper part K of the iron tube through which the air is passed.

G_1 is a peep hole for observing the starting of the arc. G_2 and G_3 are peep holes for observing the upper end of the arc. In the 600-hp furnace at Kristianssand the arc has a length of about 5 m, while in the 1000-hp furnaces, which are operated at a higher voltage, it has a length of 7 m.

The arc plays in the innermost iron tube and through it the air is passed upward. This tube has an almost unlimited life, since only on the rare occasions of lighting the arc the arc comes in contact with this tube. The upper end of the arc plays as described inside the water-cooled tube K, revolving around, so that the wear and tear is also small. The upper water cooled part is built separately so that it can be easily repaired. When in one case this part was removed after four months of operation very little wear and tear could be observed.

The air which is subjected to the high temperature of the arc is introduced near the lower electrode through eight holes, which may be more or less closed by means of the slider S. When the air enters through these holes into the innermost tube, it is already preheated. The path of the air through the furnace is indicated by arrows in Fig. 1. The air enters at c, rises upward in tube 2 and downward in tube 3 (being preheated in tubes 2 and 3), passes through the eight holes near the bottom into the innermost tube 4, where it is changed into a gas mixture containing nitrogen oxides. This gas mixture, after having risen to the top of the furnace, passes down again through the outer tube 1 and is withdrawn from the furnace through d. The water for cooling the upper portion K of the furnace enters through a and leaves through b.

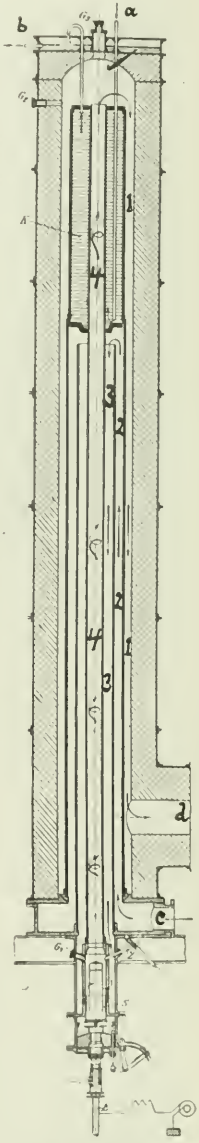


FIG. 1.—DIAGRAM OF FURNACE FOR FIXATION OF ATMOSPHERIC NITROGEN.

At the plant in Kristianssand in Southern Norway, which has been in successful operation continually since the autumn

of 1907, three phase currents are employed which are transmitted from a water-power station in the neighborhood at 25,000 volts. At the plant the voltage is reduced to 7200 (delta) the voltage per phase (star) being, therefore, 4200.

Three furnaces are connected in star. Since about 1300 kw are available each of the three furnaces is operated at about

FIG. 2.—VIEW OF FURNACES.

900 kw. Occasionally 1000-hp furnaces have been in operation and furnaces of this size will be used later on exclusively. It even seems possible to operate with equally good success furnaces of 2000 hp.

The nitrogen oxide gases leave the furnace through a channel *d* which brings them to a steam boiler. This serves as a cooling device for the gases, while the steam produced is used later for concentrating the obtained solutions by evaporation.

The arcs are in operation continually and only in case of an accident are they extinguished—for instance, when there is a short circuit on the transmission line or when the air supply is suddenly changed.

The current and voltage curves are almost sinusoidal. The power factor is nearly unity and varies in the average between 0.93 and 0.96. This is thought to be due to the fact that essentially the same air particles form the electric current conductor during several successive periods of the alternating current. The resistance variations are, therefore, less than is usually the case with arcs. Although at every moment new cold particles of air enter into the zone of the arc, their number is small compared with the air particles already in this zone.

The fact that the air remains for a long period in contact with the arc is, therefore, not a disadvantage, as had been thought by some critics. In fact, the efficiency is not reduced thereby since, as a matter of fact, this arc process operates with a higher energy efficiency than the process of Birkeland and Eyde.

It has long been recognized that two points are of essential importance to get a high efficiency: first, to produce a high temperature (this is accomplished effectively by the arc); second, to cool suddenly the gas mixture which contains the nitrogen oxides in order to "freeze," so to speak, the equilibrium of the gas mixture corresponding to as high a temperature as possible (and, therefore, containing as high a concentration of nitrogen oxides as possible). This is most effectively done by means of the cold air which always surrounds the hot air in the center of the tube. The temperature of the gas mixture when leaving the innermost tube is about 2000° C. When leaving the furnace through the channel *d*, the temperature is 850° C.

The heat balance sheet of the furnace operation is interesting, although a little disappointing. The energy of the arc is completely changed into heat. Of this total heat, however, only 3 per cent is used for the formation of nitrogen oxides; 40 per cent of the heat is recovered in form of hot water; 17 per cent of heat is lost by radiation; 30 per cent is utilized in the steam boiler. And 10 more per cent must be abstracted by water cooling from the gases after their passage through the steam boiler. The steam heat is, of course, usefully employed for evaporation, so that no further fuel is needed in the process.

It might be possible to build the furnace itself into a steam boiler, but for practical reasons this idea has not yet been tried.

The process not only has a higher energy efficiency than other processes, but yields the nitrogen oxides in a higher concentration and this is of great importance for the purpose of absorption.

The nitrogen oxides can be absorbed by alkali solutions, like soda solution or milk of lime, etc., forming nitrites and nitrates. The resulting nitrite and nitrate mixture may be directly used

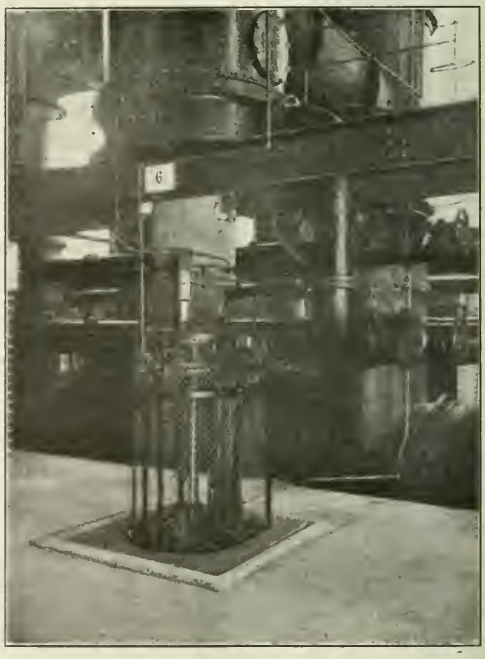


FIG. 3.—LOWER PART OF FURNACES.

as a fertilizer. The old statement that the presence of nitrites in the fertilizer has a deleterious effect on the plants has been proven to be wrong.

But the expense of the soda solution is prohibitive, and the use of milk of lime involves difficulties since when employing

ordinary absorption towers the hollow spaces in the same are liable to become clogged. More recently, Dr. Schoenherr states, they have overcome the difficulties of absorbing the gas mixture with milk of lime. They obtain thereby a calcium nitrite which has quite satisfactory properties. It has a high content of nitrogen, namely 18 per cent (against 15 per cent in Chile saltpeter and 13 per cent in "Norge saltpeter," made by the Birkeland-Eyde process).

It may be noted that it is not difficult to change the nitrite into a nitrate, if that should be necessary.

At the Notodden plant of the Birkeland-Eyde Company water is chiefly used for absorption, but this involves difficulties, and is quite a complicated process. Very large absorption spaces are required, and even then the last parts of the nitric oxide are absorbed by means of soda. Pure sodium nitrite is thus obtained.

At the Kristianssand works of the Badische Company the total nitrogen oxide gases are changed into nitrite, which is used in the Ludwigshafen works of the Badische Company. Formerly the nitrite was made by reducing Chile saltpeter by means of lead, but this method will now be given up. The market for nitrite is very limited, however, and the production of nitrite will play only a small part in the industry of the fixation of atmospheric nitrogen. With 1,200 hp the whole world's demand for nitrite can be supplied.

Since in absorption with water the quantity of nitric acid formed will be greater the more of the nitric oxide has been changed into nitrogen dioxide, it is advisable to insert a so-called oxidation reservoir between the cooling devices and the first absorption apparatus. The gases are left for some time in the oxidation apparatus to change them as much as possible into nitrogen dioxide. Absorption of the gases by means of concentrated sulphuric acid is very easy, but is naturally limited in its applications.

Dr. Schoenherr thinks that further improvements may be hoped for with respect to the methods of absorption. A process patented by Schloesing is interesting. He extracts the nitrogen oxide gases from the air by means of hot briquets of burned lime. Nitrite is first formed, but in its continuous contact with air and nitrogen oxide gases it changes into nitrate so that finally calcium nitrate is directly obtained in solid form.

If the nitrogen gases are absorbed in water, as is done at Notodden, dilute nitric acid of 30 or 40 per cent is obtained. A higher concentration can hardly be obtained by direct absorption, and other methods must be resorted to for getting a higher concentration. A direct change of the nitrogen oxide gases into nitric acid could be easily accomplished with the aid of ozone. It would then be possible to produce also the anhydride N_2O_5. A cheap method of producing ozone would, therefore, essentially simplify the absorption problem.

A large plant, four times larger than at Notodden, is now in course of erection at Rjukan, being built by a combination of the Badische Company (with which are associated the Elberfelder Farben Fabriken and the A. G. für Anilin Fabrikation of Berlin) with the Norwegian Hydro-Electric Nitrogen Company, which has developed the Birkeland-Eyde process. The Rjukan plant will be the first common factory of this combination.

The development of the Rjukan water power has already proceeded pretty far. There will be available 250,000 electric hp. The development is carried out in two steps. For the beginning 10 turbines, each of 14,000 hp, are being erected, and this plant, together with its nitrogen oxide furnaces, will start operation in 1910.

The Badische Company has also acquired the water powers of Matre and Tyn in western Norway. After the development of all these water powers there will be more than 400,000 hp available in Norway for the fixation of atmospheric nitrogen. The Badische Company also intends to erect a plant for the same purpose in Southern Germany, where the water power of the Alz River will be utilized, giving 50,000 hp.

In the conclusion of his paper Dr. Schoenherr emphasizes that this new industry needs very cheap power, but nothing else. This industry may be carried out successfully even where other industries do not exist. While the cheapness of power is the chief requirement, this industry is able to consume practically unlimited quantities of energy, because there is a large and continually increasing demand for its products—nitrates and nitric acid.

Dr. Schoenherr thinks that one may prophesy a great future for this new industry; while power cost is the main item of the cost sheet, power will be available at the same price in future times, while wages and the price of fuel and other raw materials, so far more important in other industries, are steadily increasing. It may be, therefore, expected that in course of time conditions will become naturally more favorable for this new industry.

A New Diaphragm Cell for Production of Alkali and Chlorine.

At the meeting of the Faraday Society, held on April 27 in London, a paper by Messrs. F. G. DONNAN, J. T. BAKER and B. P. HILL was read on experiments on the current and energy efficiencies of the Finlay electrolytic alkali-chlorine cell.

This cell, diagrams of which are given in the adjoining illustrations, was patented in 1906 by Messrs. Archibald and Robert Finlay, of Belfast. It is characterized by the use of a double diaphragm and central brine compartment, whereby the brine solution continuously flows under head from the central compartment through the diaphragm to the anode and cathode compartments, and from these to suitable outlets.

By a suitable arrangement of overlapping holes and slots any

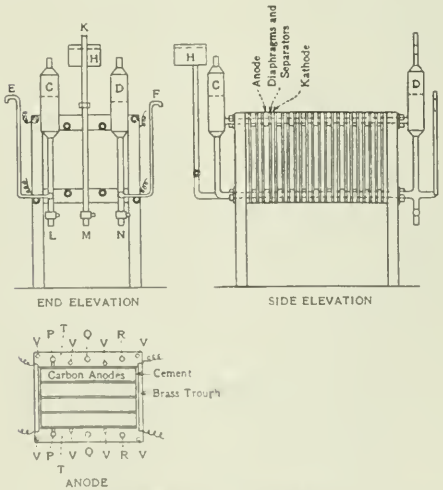


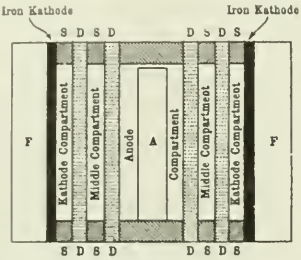
FIG. 1.—FINLAY ELECTROLYTIC CELL.

number of compartments (anodic, cathodic and brine) and corresponding electrodes can be bolted together. The various compartments are constructed by placing between the diaphragms thin rectangular or square frames of waxed cardboard about 2 mm to 3 mm thick. The various layers of electrolyte are therefore simply thin sheets of liquid, so that the electrical resistance per square foot of electrode surface is reduced as much as possible. The anodes consist of rods or slabs of Acheson graphite, the cathodes of sheet iron.

The counter flow of electrolyte greatly aids in reducing the loss of efficiency caused by electrical migration of the hydroxyl

...ward the anode, and by diffusion and convection of dissolved chlorine to the cathode.

The experiments described in the paper were carried out with small laboratory models suitable for 10 amp to 20 amp, and had as their object the determination of the current efficiencies and energy efficiencies of the cell. For this purpose the asbestos diaphragms sold for electrolytic purposes by Bernfeld, of Leipzig, were employed. It was found that these



S = Separator, A = Anode, D = Diaphragm, F = Frame.

FIG. 2.—HORIZONTAL SECTION.

diaphragms could be used continuously for a month without suffering any serious damage. Purified brine of density 1.18 (about 4.45 normal) was employed in the experiments.

The following table of figures gives an idea of the average results obtained, using as cathode diaphragm a 2-mm asbestos board, slightly loaded with ferric hydroxide, and as anode diaphragm a 2-mm (untreated) asbestos diaphragm.

Brine (density = 1.18). Temperature, 17 – 19°. Current density = 0.0217 amp/sq. cm. Average voltage = 3.37.

Grms. NaOH per 100 grms. catholyte liquor.	Amp-hour efficiency.	Watt-hour efficiency.	Grms. NaOH per kilowatt-hour.
4	98.0%	66.9%	434
5	96.5%	65.9%	428
6	94.5%	64.5%	419
7	93.0%	63.5%	412
8	91.0%	62.1%	403
9	89.0%	60.7%	394
10	87.5%	59.7%	388
11	86.5%	59.0%	383
12	83.5%	57.0%	370
13	81.5%	55.6%	361

As regards anodic efficiencies, it was found that when making 7 per cent caustic the anode gases contained 98.4 per cent chlorine, when making 13.6 per cent caustic, 94 per cent chlorine. It should be remarked that all the above figures were obtained

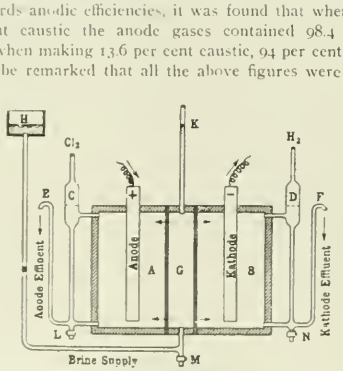


FIG. 3.—PRINCIPLE OF FINLAY CELL.

with anodes of dense amorphous carbon, as at the time of the laboratory tests anodes of Acheson graphite were unfortunately not available.

The experiments show that it is possible with the Finlay cell to make very much stronger alkali at much higher current- and energy efficiencies than in single-diaphragm cells with non-circulating electrolyte. So far as published data go, the results obtained with the Finlay cell appear to be superior to those obtained with the Aussig "bell jar" process, especially with regard to energy-efficiency.

Mr. Robert Finlay explained that certain disadvantages inherent in the small cell tested by the authors were eliminated in the large units. He believes that in its latest form the cell left little room for further improvement. Solutions containing 8 grms. caustic soda per 100 cc could now be made at a voltage of 3 from brine at ordinary temperatures, and with a current efficiency of 98 per cent, a yield of 40 per cent higher than that of the most successful electrolytic process now worked in England. One of the chief features of the cell was the absence of secondary reactions.

The Laws of Heat-Transmission in Steam Boilers.

On Jan. 14 Dr. J. T. Nicolson delivered a suggestive lecture before the (British) Junior Institution of Engineers, of which he had been elected an honorary member. In his address, which we reproduce in abstract from the London *Electrical Review* of May 7, he gave the results of experiments which he had carried out at Manchester during the past four years, with a view to ascertaining the facts regarding the transmission of heat from the flue gases to the water in steam boilers.

The subject has been attacked as long ago as 1874 by Prof. Osborne Reynolds, who laid down the principle that the heat transferred is nearly proportional to the speed of flow; in 1897 Mr. T. E. Stanton confirmed the truth of this law for cases in which water only was employed, and in 1899 Prof. John Perry, in his book on the "Steam Engine," remarked that an immense increase in the rate of evaporation ought to be obtainable when a good scrubbing action was established on both sides of the metal. The Geological Survey of the United States took up the matter on the strength of Professor Perry's remarks, and further verified the law.

Introducing the subject of his own tests, the author recalls that the ordinary formula for heat flow across a plate is

$q = k\,(T - t)/e$ British thermal units per hour per sq. ft.

where T and t are the temperatures (Fahr.) of the two surfaces, e is the thickness of the plate in inches, and k is the thermal conductivity (= 450 for wrought iron or mild steel). But this formula gives results some 200 times as great as are realized in practice.

The formula of Rankine and Peclet, $Q = (T - t)^2/a$, for the transfer of heat from the gases at temperature T to the water at t, when combined with the foregoing, shows that the temperature of the two sides of the plate can differ by only 7 deg. or 8 deg. Fahr., most of the drop (about 1,140 deg.) taking place between the hot gases and the plate. The constant a is usually taken as 200.

The author believes that there is an exceedingly thin stationary film of gas on the one side, and of water on the other, which oppose very great resistance to the flow of heat; thus, the use of copper instead of steel, or thin tubes instead of thick, in the hope of obtaining a better heat transmission, is futile.

By increasing the speed of the gases, however, to 10 or even 50 times that which now obtains, the cooled films adhering to the surface of the plate are torn off and whirled into the body of hot gases, while new films take their places. The communication of heat from a film to the plate is practically instantaneous and if the cooled films can thus be rapidly replaced, the rate of transfer of heat from the gases to the plate can be enormously accelerated

An evaporation of 45 lb. per square foot per hour has been secured by the author, by simply increasing the rate of flow of the gases through the flue of a Cornish boiler, beyond the bridge; this was effected by nearly filling up the flue with an internal cylindrical water vessel of boiler plate, leaving only an annular space 1 in. wide, 40 in. in diameter, and 10 ft. long. The heat transmitted through the plates was 34,450 b.t.u. per

square foot per hour, about eight times the rate usually obtained, the speed of the gas current being about 330 ft. per second.

This experiment shows that the rate of heat transference is directly proportional to the speed of flow of the gas, and as Rankine and Peclet's formula takes no account of the speed, it obviously breaks down.

The power required to drive the exhausting fan amounted to about 4¼ per cent of the whole power available; on the other hand, the output of the boiler was increased to eight times the normal, and there would be therefore a great saving in the cost of boilers, floor space, etc., for equal output.

In 1905 Dr. Nicolson conducted a series of experiments on the flow of heat from warm compressed air to water both flowing in concentric pipes; these were described in the lecture in detail, and the problem of steady flow of heat under these conditions was mathematically analyzed. Other experiments of his own and other investigators were also discussed at length and a general formula was arrived at for the heat transference from a gas flowing along a flue, as follows:

$$Q = \left[\frac{\phi}{200} + \frac{1}{40}\sqrt{\phi}\left(1 + \frac{1}{m}\right)\rho u\right](T - \Theta)$$

where

Q = b.t.u. transferred per hour per sq. ft. of flue surfaces.
T = temperature of gas flowing along the flue (deg. Fahr.).
Θ = temperature of metal wall of flue.
$\phi = \frac{1}{2}(T + \Theta)$ = mean film temperature.
ρ = density of gas, lb. per cu. ft.
u = speed of gas, ft. per second.
m = hydraulic mean depth of flue or pipe $= a/c$.
w = lb. of gas flowing per second.
a = area of flue in sq. in.
c = perimeter of flue in inches.
$\rho u = w/a$.

This formula was also applied to actual data and shown to give results in good agreement with those obtained in practice and it was shown how the old Rankine formula gave approximate agreement with results over customary ranges of temperature and at ordinary speeds of flow, the constant a being arbitrarily modified by the users to suit circumstances.

As increased draught was ordinarily accompanied not only by higher speeds of flow, but also by a greater rate of combustion of fuel, users of the old formula accounted for the enhanced rate of evaporation per foot of heating surface, on the ground that the gas was at a higher temperature. As a matter of fact, the increased rate was due almost entirely to the higher gas speed, and only in a minor degree to the higher temperature. By the exercise of taste in the choice of the constant, the old formula was capable, by good luck rather than by intelligent guidance, of representing the results of boiler trials to a fair degree of approximation. The old formula is, however, essentially erroneous, while the new formula, being a true law of nature, holds both under ordinary conditions and under extreme circumstances.

As regards the bearing of his results upon boiler practice, the author stated that a reduction of the heating surface to even one-tenth of that now usual can be made, without increasing the chimney temperature or lowering the efficiency. Or if the surface is unchanged, but the cross-sectional area through the flues reduced, a much lower chimney temperature and higher efficiency can be secured. Draughts of 10 in. or 20 in. of water gage, induced by fans, should always be employed for economical working.

If the boiler is designed on the economizer principle, with strict attention to counter-currents, methods of flow, a chimney temeperature of 100 to 150 deg. Fahr. can be attained, corresponding to a boiler efficiency of over 95 per cent. Thus the margin of additional evaporation more than covers the power required for the fan, and therefore higher economies are attainable, with smaller boilers, less floor space and lower first cost than at present.

Combustion can be carried on in a lined chamber, ensuring perfect smokelessness. The author believes that the proposed new method of working is capable of effecting radical improvement in steam-boiler practice, without which the steam engine cannot retain its pre-eminence in the economical production of power.

Niagara Falls Meeting of the American Electrochemical Society.

The fifteenth general meeting of the American Electrochemical Society, held in Niagara Falls, Canada, from May 6 to 8, turned out an immense success in every respect. The whole program had been arranged with skill and foresight by the officers of the society and by the local committee.

The official Entertainment Committee, the unofficial Section Q, and all the individual Niagara Falls members rivalled each other in their efforts to make everybody feel at home. With equal courtesy the large party of visiting ladies were entertained by the ladies' committee at a reception tendered by Mrs. Acheson, and on several excursions.

The number of members and guests registered was 323, of which 187 were members and 136 guests.

At the business meeting held on May 7 the annual reports of the officers were presented, which show the society to be in a very flourishing condition with respect to membership and finances.

The result of the election of officers for the next year was announced as follows: Dr. Leo H. Baekeland was elected president to succeed Dr. Acheson, who now becomes the junior past president. Dr. J. W. Richards and Mr. P. G. Salom were re-elected vice-president and treasurer respectively. Messrs. F. J. Tone, Carl Hering and W. D. Bancroft were elected vice-presidents for two years; Messrs. E. R. Taylor, W. L. Miller and W. H. Walker managers for three years.

The new president, Dr. Leo Hendrik Baekeland, is Flemish by birth. He was formerly associate professor of chemistry at the University of Ghent and professor at the Higher Normal School of Bruges. He has been a resident of this country for twenty years and is widely known through his original chemical research work, his invention of velox paper and the so-called gaslight printing papers used in photography, his improvements of the Townsend cell for electrolytic production of caustic and chlorine, and his invention of bakelite. He also published some philosophical essays and a book on travel. His research laboratory is situated on his property, "Snug Rock," in the wooded outskirts of Yonkers, N. Y., overlooking the Hudson.

The program of papers was excellent and filled four long sessions on Thursday morning and afternoon, Friday morning and Saturday morning.

On Friday afternoon visits were paid to the various power companies on the Canadian side. On Saturday afternoon a most interesting visit was made to the works of the Development & Funding Company, where the Townsend cell for the electrolytic production of caustic soda and chlorine is in operation, and to the plant of the International Acheson Graphite Company. Since the latter plant was described in our last issue, page 187, and the former in our Vol. V, page 209, this reference must here suffice.

On the evening of Thursday, after Dr. Acheson's presidential address, a very enjoyable smoker was held, which was followed by a meeting of Section Q, with Mr. Tone in the chair, and

Messrs. Lidbury, FitzGerald, Bennie, Hooker, Cravath, Banner tt, Backeland, and Saunders as the ringleaders. The fun began with an alphabetical roll call in form of cartoons of well-known members, thrown on the screen by lantern slides. Then followed a mock trial of a distinguished electrochemist accused of having transferred his affections to photochemistry; it ended with an acquittal. A series of short experimental lectures followed, very amusing and very clever, the program being as follows: P. McN. Bennie on the use of electrolytic iron for the testing of abrasives; A. H. Hooker on a new method of daylight development; F. A. J. FitzGerald on the application of the ultramicroscope to electrolytic discovery; F. A. Lidbury on some electrochemical "effects." And then came more songs.

The banquet on Friday evening was a delightful affair. Dr. Bancroft was an excellent toastmaster. Dr. Acheson as retiring president and Dr. Backeland as president-elect spoke on the work and the future of the society. Major Ernesto Stassano's toast on electrometallurgy brought out great enthusiasm. Mr. Kirchhoff spoke for the technical press, Mr. Coho on the social side of the society. Dr. Richards made announcements on the work of Sections A to Q at the meeting of the American Electrochemical Society to be held in Niagara Falls 20 years hence. Dr. Whitney spoke for the American Chemical Society, and Professor Burgess for the American Institute of Electrical Engineers. Dancing followed.

On the evening of Saturday, the Niagara Club tendered to the society an open house. This entirely informal but very enjoyable affair closed the meeting, which will always be remembered with pleasure by all who attended it and which will go down into history for the importance of the proceedings.

During the meeting a little exhibition had been arranged in the meeting hall of products of the electric furnace. Some fine exhibits of their products were made by the Electrometallurgical Company (ferro-alloys), the Carborundum Company (carborundum, silicon, etc.), the Norton Company (alundum and articles made from alundum). The FitzGerald and Bennie Laboratories had various interesting exhibits relating to the electrometallurgy of iron and steel, including photographs of the 15-ton Héroult furnace at Gary and specimens of the first electric steel rail rolled in the United States by the Maryland Steel Company, the steel being made in the Roechling-Rodenhauser furnace in Germany. Mr. John A. Yunck exhibited samples of electrolytically prepared white lead and colors. Mr. Maximilian Toch had interesting exhibits relating to the corrosion of steel. The Dossert Electrical Company, of New York, showed their connectors for making a solderless joint between the cables and the electrodes of electric furnaces (see description in our April issue, page 170). Dr. Backeland exhibited interesting samples of bakelite, showing various electrical and electrochemical applications.

In the following we give abstracts of all the papers presented at the meeting:

Electrometallurgy of Iron and Steel.

Practically the whole of Thursday was devoted to a symposium of papers on the electrometallurgy of iron and steel. For the success of this symposium much credit is due to Messrs. FitzGerald and Bennie, of Niagara Falls, who had been in charge of the arrangement of this special feature of the program, and to the secretary of the society, Professor Richards, of Lehigh University.

AMERICAN ELECTROCHEMICAL SOCIETY CONVENTION, NIAGARA FALLS, CANADA.

In calling the meeting to order, the president, Dr. Acheson, called attention to the distinctly international flavor of the occasion. For the first time the society met on Canadian soil and electrometallurgical engineers from all countries had prepared papers for the meeting.

In behalf of the Canadian Government Dr. Eugene Haanel, director of mines, of Ottawa, Canada, welcomed the society in

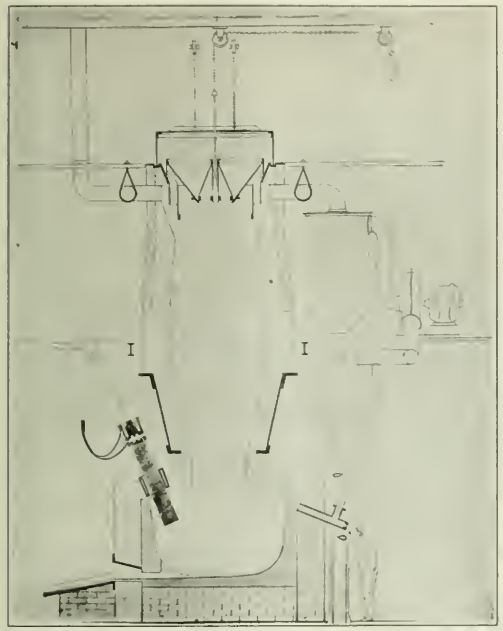
EUGENE HAANEL.

a little felicitous speech. It is unnecessary to mention in this journal the prominent part which Dr. Haanel has taken in the advance of the electrometallurgy of iron and steel by his official reports on this subject (see our Vol. II, pages 475 and 479, and Vol. IV, page 865). It was thus but natural that Dr. Haanel should follow up his speech of welcome by presenting the first paper, in which he gave an account of his recent visit to Sweden,

where he examined a new electric furnace for iron-ore reduction.

Electric Furnace Pig Iron in Sweden.

The furnace described in the paper of Dr. Eugene Haanel was designed by Messrs. A. Grönwall, A. Lindblad, and O. Stahlhane for the reduction of pig iron from ore. These three engineers have been carrying out an extended investigation on the electrometallurgy of iron ore for a series of years for a syndicate of Swedish iron masters and manufacturers, the Elektro-



SWEDISH ELECTRIC PIG IRON FURNACE.

metall Company, of Ludwika, Sweden, having been formed for this purpose. These three engineers concentrated their attention to the construction of a suitable furnace.

Dr. Haanel first gave an account of the former experiments made under his supervision at Sault Ste. Marie with a Heroult furnace for pig-iron reduction, and of the recommendations which he had made at the end of his official report (see our Vol IV, page 265). These recommendations have now been made use of in the design of the Swedish furnace of Gronwall, Lindblad, and Stahlbane.

This furnace is shown in the adjoining diagram. It is really a combination blast-furnace and electric-furnace design. A vertical shaft is superimposed upon and opening into a large smelting chamber at the bottom. The latter has the form of a large crucible with an arched roof. The three electrodes supplied with three-phase currents are suspended into this lower chamber; one of the electrodes is shown in the illustration at the left side. The gaseous products of reaction leave the furnace at the top and are blown back through tuyeres into the lower smelting chamber, the object being to cool the roof of the furnace chamber above the electrodes. This is, in fact, the chief feature of the design. There is a peep-hole through which the attendant (shown at the right-hand of the diagram) can observe the roof of the smelting chamber; if he finds that the cooling effect is not sufficient, he permits more cooling gases to be blown through the tuyeres. There is, therefore, always a free space between the charge in the hearth and the arched roof and in this free space the gases circulate and cool the lining.

In the presence of Dr. Haanel the furnace was subjected to a 12-day run. The voltage was 37, the current 6000 amp to 7000 amp. Dr. Haanel thinks the furnace was too big for the available power.

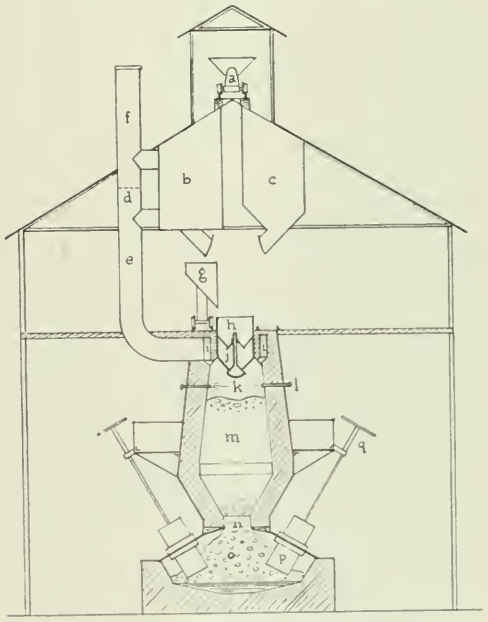
Charcoal was used as reducing agent, the consumption being 605 lb. per long ton of pig iron.

The electrodes required no regulation, the feeding being automatic. For five consecutive days they required no attention. Their consumption was 11 lb. per long ton of pig iron.

The tests proved that there was no clogging of the charge in the contracted neck of the shaft where it goes down into the smelting chamber. Further, the free space between the charge and the arched roof of the smelting chamber was maintained open during the run. The consumption of energy was remarkably uniform. The furnace forms, therefore, an ideal load for a power plant.

Although the circulation of the gases was not started until the end of the run, the tests were sufficient to prove that the cooling of the arched roof by the gases worked satisfactorily.

As was already noticed in our April issue, this furnace will be used in a commercial electric pig-iron plant in Norway. The first installation will be built this summer, and includes two iron-ore reduction furnaces of 2500 hp each, and two steel furnaces of 600 hp each. All furnaces will be operated with two-phase current. The plant will later be enlarged by erecting four more iron-ore reduction furnaces of 2500 hp each and four steel furnaces of larger size than 600 hp. The installation will include a rolling mill.



CALIFORNIA ELECTRIC PIG IRON FURNACE.

(*a* Supply car, *b* ore preheater, *c* charcoal bin, *d* bypass damper, *e* gas flue, *f* gas stack, *g* charging car, *h* upper hopper, *k* annular space, *l* lower hopper, *k* combustion chamber, *l* air inlets, *m* bosh and reducing stack, *n* contracted throat, *o* melting crucible, *p* electrode, *q* electrode gearing.)

Electric-Furnace Pig Iron in California.

Mr P McN. BENNIE (FitzGerald & Bennie Laboratories, Niagara Falls, N. Y.) followed Dr. Haanel with an account of what has been done in the United States in attempts to create an electric pig iron industry. He first sketched the

peculiar local conditions in California, which he has studied carefully during a recent trip to the Pacific Coast and which appear to make such an attempt feasible.

Coal rates at some Pacific points are peculiarly favorable to electric furnace treatment of iron ore. The present market there is not less than 150 tons a day, the supply being imported or brought a long distance by rail. Some foundries even go to the extent of melting promiscuous scrap in cupolas. Pig iron brings $9 to $10 the ton above Pittsburg base, market quotations varying from $23 to $26 the ton, whether of domestic or foreign origin.

Conditions are not favorable to the operation of a blast furnace to fill this demand. While iron ores might be had at reasonable rates the carbon problem is serious. The only plentiful fuel is California asphaltic petroleum, which cannot be used for the purpose. Metallurgical coke brought from the East by rail would be out of the question, while imported coke is not only high in price but irregular as to supply and therefore variable in price. The California demand for coke is met by importation in cargo from Germany, Belgium, and Australia. The coke is bid for upon arrival, hence the irregularity both as to price and supply. The price may be anywhere between $10 and $13 the ton. Therefore a blast furnace plant would be an investment of uncertain value.

With electric smelting of iron ores the cost of carbon becomes of less importance, the quantity used being only about one-third that required for the blast furnace. Further charcoal can be used. If it is possible to assemble cheaply iron ore, limestone and electric power at one place, we could afford to use coke or charcoal at a price prohibitive so far as a blast furnace is concerned.

Such conditions may be found in several places in California within easy reach of the principal market. One such location has been chosen for exploitation by the Noble Electric Steel Company.

The equipment of the Noble Steel Company's plant is described in the paper (reported below) by Professor Lyon. In supplementing this paper Mr. Bennie stated that the experimental 160-kw furnace was run for a period of about 40 days, during which time data were gathered to be used in the design of the present 1500-kw furnace. The results thus experimentally obtained make it not unreasonable to expect a power consumption around 0.25 hp-year per ton. Without allowing anything for by-products, charcoal will probably cost $9 a ton, of which one ton should be sufficient for about three tons of pig iron.

If the figures obtained with the smaller furnace can be realized in the 1500-kw furnace, the cost of pig iron should be in the neighborhood of $15. The freight to San Francisco should not exceed $3 per ton. Now when it is considered that the product will be charcoal pig iron, and should command a higher price than ordinary blast furnace pig iron, there seems to be a comfortable margin of profit for the manufacturer.

Another point not touched by Professor Lyon is that such high-grade pig iron, coming from the electric furnace in a molten state, would be most desirable starting material for steel. The liquid metal could be tapped into a second electric furnace and refined to steel, particularly in view of the very pure iron ore available, or a modified method like the Lash process could be used. The added expense would be less than the added value, so there would be a distinct gain for the manufacturer.

Noble Steel Co. Works in California.

Prof. Dorsey A. Lyon, general manager of the Noble Steel Company at Heroult-on-the-Pitt, Shasta County, Cal., contributed a paper on the equipment of this pioneer electric pig-iron plant of this country. For 25 years or more a company known as the Shasta Iron Company has owned a deposit of magnetite, located about seven miles from the mouth of the Pitt River, in Shasta County, Cal. The ore is a very pure magnetite, containing 69.9 per cent iron, and having on the average the following composition: 89.4 Fe_3O_4, 7.3 Fe_2O_3, 0.10 MgO, 0.18 MnO, 2.40 SiO_2, 0.011 P, 0.009 S. It occurs at the contact between limestone and diorite and the ore body is remarkably uniform.

The limestone is also of excellent quality, with an average composition of 1.2 per cent SiO_2, 0.5 Al_2O_3, 1.1 MgO, 53.8 CaO, 0.2 FeO, equivalent to about 98 per cent calcium carbonate.

In 1907 the possibilities of these deposits were brought to the attention of Mr. H. H. Noble, president of the Northern California Power Company, which practically supplies all the electric power for mines and smelting in Shasta County. After some correspondence with Dr. Paul Héroult, plans were made for the erection of an experimental plant at a point called Héroult, on the Pitt River.

In July, 1907, the first furnace having been completed, experimental work was begun. This furnace was a 1500-kw. three-phase furnace of the resistance type. It was soon found that

PLANT OF NOBLE ELECTRIC STEEL CO., HEROULT-ON-THE-PITT, SHASTA CO., CAL.

the type of furnace first used presented mechanical difficulties which made its commercial use impractical, and so it was closed down. Since that time the experimental work has been carried on in a 160-kw furnace, and from the results obtained in this furnace, and its method of operation, another 1500-kw furnace was designed and built, which, at this time, would probably be in operation but for the heavy storms of January and February, which caused practically a cessation of construction work during that time.

At present the iron ore is mined by quarrying. From the mine the ore is to be taken to the smelter by means of a surface and gravity tramway. The distance from the mine to the top of the gravity is about 6000 ft.

The furnace design is shown in the illustration on page 251. Above the crucible at the base of the furnace is a superposed stack which resembles an ordinary blast furnace and which has a bosh communicating with the crucible.

In the operation of the furnace, the ore, mixed with its proper proportion of fluxing materials will be fed unto a preheater (*b*) wherein it is to be dried and heated. The source of the heat for the preheater is to be derived from the products of combustion from the combustion chamber (*k*) at the top of the stack, which will be let into the base of the preheater through a flue (*e*) which communicates with an annular chamber surrounding the top of the stack and communicating with the production chamber (*k*) through openings or ducts (*l*).

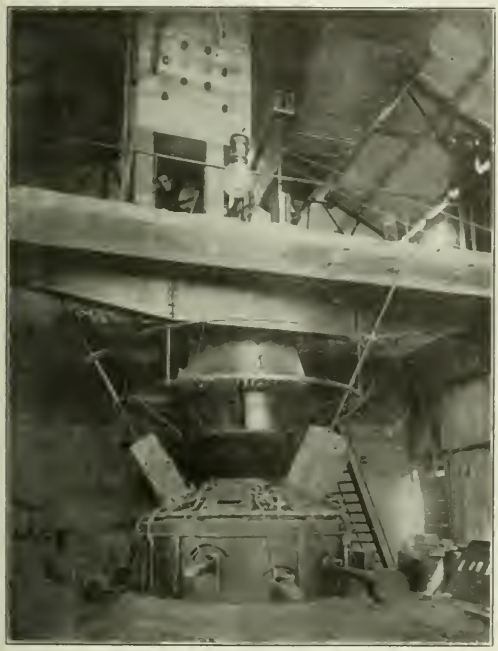
A scale car (*g*) runs upon a circular track round the top of the stack and will alternately receive a charge of ore and flux from the preheater (*b*) and a weighed charge of carbon from the carbon hopper (*c*), these charges being delivered alternately by proper mechanism into the body of the furnace.

In the operation of the charging device a charge of ore and flux will first drop into the upper portion of the hopper, the bell (*h*) being closed, and after the charge is properly distributed about the hopper the bell (*h*) is lowered so as to per-

mit the charge to pass into the lower compartment of the hopper, the upper bell being then closed and the lower bell (*f*) opened, so as to permit the charge to pass into the stack. The charge of carbon is then fed into the furnace through the charging device in the same way.

The charge will be kept at about the level of the dotted line shown in the stack. Above the level are small openings in the stack with suitable valves for admitting the requisite amount of air to burn the gases resulting from the reduction of the ore in the lower part of the stack, thus still further heating the charge, and, as above stated, these waste gases will then pass through the preheater (*b*) thus preheating and drying the ore before it is charged into the furnace.

The electrodes, six in number, are arranged equidistantly around the furnace. The electric current passing through be-



OLD ELECTRIC PIG IRON FURNACE AT NOBLE ELECTRIC STEEL WORKS.

tween them melts the charge, and the molten metal and slag are collected in the crucible, from which they are drawn as in ordinary blast-furnace work.

Charcoal is used as the reducing agent in the electric furnace plant. The description of the charcoal plant forms the concluding part of Professor Lyon's paper.

The retorts are cylindrical in shape and are mounted in an upright position in concrete and brick, there being four retorts to a battery. The wood is placed in cages similar in construction to the retorts themselves, and these cages are then placed in the retorts.

The volatile products obtained during the distillation of wood will be condensed by means of condensers in building and then pumped to the refining building, where the condensed vapors will be refined into commercial products.

After the distillation of the wood is complete the cage containing the charred wood is to be taken from the retort and placed in a cooling stand until its temperature has been lowered below the flashing point of the charcoal.

In the meanwhile another cage containing a charge (two cords) is placed in the retort and the charring begins, together with the accompanying driving off of the volatile constituents. The cages in which the work is placed are air-tight, the opening for the escape of the volatile constituents being closed automatically when the cage is lifted from the retort.

When the charcoal has cooled below its flashing point, it is to be discharged into the charcoal storage bin, which is cylindrical and entirely closed except for an opening near the top just large enough to receive the bottom of the cage through which the charcoal is discharged. From the charcoal bin the charcoal is to be taken to the furnace building and hoisted to the charging floor and dumped into the charcoal hopper (*c*).

The wood is reduced to charcoal containing about 95 per cent carbon, the condensable part of the vapor being collected in tubular condensers, the uncondensable gases being led under the furnace and burned. The quality of charcoal that can be made from our wood supply is very good, the following being specimen analyses of charcoal from their ordinary bee-hive ovens:

	I.	II.	III.
Water and volatile matter	5.3	7.8	6.5
Ash	0.5	0.7	0.6
Carbon	94.2	91.5	92.9

It is also the intention to introduce at this plant an electrolytic method of making lead acetate, for which there is a certain demand on the Pacific Coast. The entire plant is designed to produce charcoal at low cost for labor, for the utilization of waste heat and saving of time.

Electric Furnace Reduction of Iron Ore.

Prof. J. W. RICHARDS, of Lehigh University, compared in his paper the reduction process in the blast furnace and in the electric furnace.

An outline of the principles of blast-furnace practice is first given. Fuel is needed to provide heat and reducing effect. The heating effect is almost entirely produced by the combustion of the larger part of the fixed carbon (non-volatile carbon) of the fuel to carbon monoxide before the tuyeres. This combustion fills two functions. It provides the high temperature necessary to melt down the iron and slag, and it provides large quantities of reducing gas, practically identical in composition with producer gas (30 to 35 per cent CO, 1 to 2 per cent H_2, rest N_2), which performs in the upper part of the furnace the larger part of the reduction done in the furnace.

The amount of fuel used in a blast furnace is determined by the amount which must be burned at the tuyeres to produce the necessary smelting temperature, and not by the amount necessary to perform the reduction of the metallic oxides. The amount necessary for performing the reductions taking place in the furnace is only one-third to one-half of the amount necessary to be burned to provide the smelting heat.

The proportion of carbon ordinarily consumed at the tuyeres is 9 atoms (108 parts) of carbon for each molecule of iron oxide (160 parts) reduced by the carbon monoxide gas. The chemical equation is

$$Fe_2O_3 + 9\,CO = 2\,Fe + 3\,CO_2 + 6\,CO.$$

This equation shows that only one-third of the carbon monoxide produced before the tuyeres in generating the smelting temperature is utilized in reduction, while two-thirds escapes unused.

On the other hand, in the electric smelting furnace all necessary heat is supplied by electrical energy, no blast is blown in, and, therefore, all the solid carbon is utilized for reduction (always excepting the small amount which dissolves in the pig iron). In calculating the amount of carbon necessary to thus reduce the iron oxide we meet at the outset with this difficulty. What proportion of the carbon will form CO_2 and what proportion CO? We know that when reduction takes place at a very high temperature, CO is almost the only product; but as this passes more or less slowly through the cooler

portions of unreduced charge CO_2 is formed in increasing amounts until at a low red heat, given sufficient time, about half the CO may be converted into CO_2. The formulas corresponding to these two extremes are

$$Fe_2O_3 + 3\,C = Fe_2 + 3\,CO.$$
$$Fe_2O_3 + 2\,C = Fe_2 + CO + CO_2.$$

Comparing this with the ordinary blast furnace, which requires 0 C put into the furnace for the reduction of Fe_2O_3, we see that 3 C, or one-third, as much carbon is the greatest amount necessary in the electric furnace reduction, and 2 C or between one-third and one-fifth as much, is the smallest amount necessary. Further, the uncertainty as to how much CO_2 can be formed in the electric furnace reduction is perhaps the chief difficulty in running the electric furnace.

A numerical example is then given and finally it is emphasized that the electrical reduction of iron ore differs radically from blast furnace practice in one essential particular, viz., that since no air is blown in, any excess of carbon above that consumed in reduction must remain unused, accumulate and eventually clog the furnace. The amount to be used as a minimum cannot, moreover, be calculated until we know how much CO_2 will be formed in reduction, and that is an unknown quantity unless arrangements are made so that none can be formed.

A number of interesting suggestions are then made on a possible combination of blast and electric furnace with the object in view of avoiding the accumulation of excess carbon in the furnace. The best solution of this difficulty, in Dr. Richards' opinion, is to provide tuyeres by which air can be sent into the crucible of the furnace, and thus burn any accumulation of carbon. A given quantity of air will always burn a given quantity of carbon, and therefore the cure would seem to lie in having a variable supply of air, which is increased whenever the falling resistance of the furnace indicates that carbon is beginning to accumulate, and diminished to a small minimum supply, only enough to keep the tuyeres open when the furnace is in good electrical running order. It would represent a combined electrical and blast furnace, with the blast so regulated as to overcome the chief difficulty of the purely electrical furnace—the accumulation of unused carbon in the crucible.

It may be quite possible, by some such device as Mr. Taylor's large electrical furnace, to practically combine the blast furnace and the electrical furnace. Dr. Richards is "quite confident that any practicable method of introducting electrical heat into the crucible of a blast furnace will result in large economies in the furnace working. Only one-quarter of the heating power of the fuel is developed around the blast tuyeres, and yet if half of this could be replaced by electrically generated heat an economy of 50 per cent could in all probability be reached upon the fuel bill. To put it into figures, it takes 1.2 tons of coke to make a ton of pig iron in the blast furnace and about three-quarters of a ton is burned by the blast producing at the smelting zone, about 25 per cent of the calorific power of the coke. If electrical energy could be made to supply only one half of this, the furnace would make iron with half the previous coke supply, that is, with 0.6 ton of coke per ton of pig iron, and this with an expenditure of electrical energy equal only to 12.5 per cent of the calorific power of the coke, that is, equal to the calorific power of but 0.15 ton of coke.

"The question of economy in this case will not be, then, the simple replacement of fuel heat energy by an equivalent amount of electrical heat energy, but the comparison of fuel-heat energy with the cost of one-fourth its amount of electrical heat energy. This may be quite possible in many localities and the combined furnace would work more regularly than a purely electrical furnace. The question awaits the coming of the electrometallurgical engineer who can make practicable the requisite combination. A possible solution may be to use cheap electrical power to superheat the hot blast, and thus to make the blast itself the agent for carrying electrically developed heat into the furnace."

Discussion.

The four papers of Haanel, Bennie, Lyon, and Richards all referring to pig-iron reduction in the electric furnace, were discussed together.

Dr. Haanel referred to the attempt made at the Noble Steel Company's plant to burn the carbon monoxide gases in the top of the shaft to carbon dioxide for preheating the charge. The same attempt had been made in the Soo experiments, but it had been found that this caused the charge to stick and clog, and much labor was required to poke and feed the charge downward.

Mr. Bennie replied that no trouble of this kind was experienced at the Noble plant. Their charge does not fill the whole shaft to the top and the carbon monoxide is burned in the space above the charge. The preheated charge moves freely downward without extra help.

Dr. Richards referred to the absence of nitrogen in electric furnace pig iron as compared with blast-furnace pig iron. This may make electric furnace pig iron specially suitable for steel making. At least this should be investigated by tests.

Dr. Moldenke said the presence of oxygen causes more trouble than nitrogen. It is of decisive importance whether pig iron is good or poor. The content of oxygen in electric pig iron should be tested.

Mr. Bennie said that at the Soo and in California considerable difficulty had been experienced with the slag. Under the highly reducing conditions a lot of silica is reduced. The silicon goes into the iron. The slag is sticky. The best way is not to add any silica.

This finished the discussion of the making of pig iron in the electric furnace. All the following papers referred to the use of the electric furnace for making and refining steel.

Stassano Steel Furnace.

The first paper on electric steel furnaces was from the distinguished Italian electrometallurgist, Major Ernesto Stassano, who was himself present. His paper was read in abstract by

ERNESTO STASSANO.

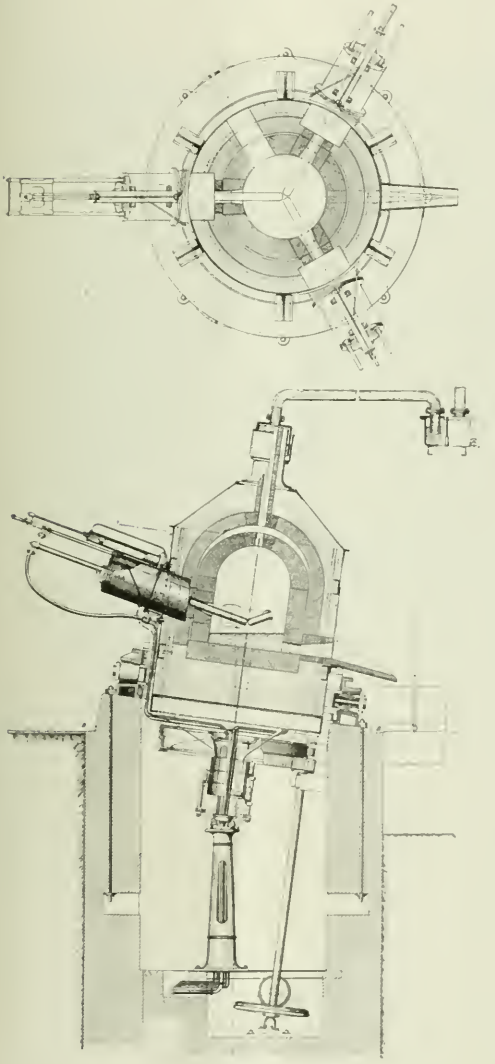
Prof. J. W. Richards. Since we published an exhaustive article by Major Stassano on his furnace in our August issue of last year (Vol. VI, page 315), a concise summary of his present paper must suffice here.

Major Stassano first made some remarks on the strong competition which now exists between different electric furnace designers and engineers; this is but natural and is justified "to a certain point." A review was then given of the evolution of the design of arc, resistance and induction furnaces. The principles are not new. Nor is there any new mysterious force or power

brought into the metallurgy of iron and steel. In all the different types of electric furnaces for iron and steel the electrical energy has no other function but to be transformed into heat.

The Stassano furnace is a rotary-arc furnace, heating the charge by radiation from above. It is a hermetically closed apparatus, thus ensuring a perfectly neutral atmosphere. The heat of the arc and the closed apparatus make it possible to get the highest temperature. Further, the entrance of any foreign substances is perfectly eliminated. It is quite possible to work always with a full charge.

In the tightly closed Stassano furnace, the electric arc operates like an "enclosed arc" of great length and burning very



SECTIONS STASSANO FURNACE.

quietly. Mr. Stassano thinks that in furnaces of the type having two arcs in series, each arc playing between electrode and slag, some entrance of air cannot be avoided. He also claims that the induction furnace has a slightly oxidizing atmosphere.

As to the requirement that the charge should not get into contact with any foreign substance, he thinks that this is fulfilled only in the Stassano furnace and the induction furnace.

Mr. Stassano replied at some length to the criticisms which have been raised against his furnaces as being complicated on account of the mechanism for rotation. "A locomotive has many parts, but it works perfectly well." So does his furnace.

There is no real complication in the mechanism. As an experience of many years, Mr. Stassano stated, that the operation of his furnace was perfectly reliable and free from troubles. He considers a high density in electrodes as economical.

The rotation of the furnace is only an apparent complication. The charge has a natural automatic agitation, but the rotation of the furnace helps further in producing an absolutely uniform and homogenous metal.

Little heat is lost by radiation. As a matter of fact, the outside of the furnace is cold.

Mr. Stassano gave two specific examples of the application of his furnace to steel making. Several tables of this kind were given on pages 316 and 318 of our Vol. VI.

At the conclusion of his paper a diagram was given of the fluctuation of power during a whole day's run of the Stassano furnace. It showed a very great regularity of power consumption.

Keller Electric Steel Process.

Quite an extensive paper was contributed by Mr. CHARLES ALBERT KELLER, managing director of the Société des Etablissements Keller-Leleux, Livet Works, Isere, France. In the first

C. A. KELLER.

part of his paper he described a **conducting non-carbon hearth.**

Conducting hearths, made of carbon, are nothing new in electric-furnace practice. But for steel smelting or refining it is essential to avoid carbon, so as not to change the carbon content of the steel.

However, non-carbonizing conducting hearths have also been known for a long time. They may be constructed in various ways. The entire furnace bottom may be made of metal and water-cooled, but this construction is practically impossible, as it is not durable and represents a constant source of danger.

Another construction is to use one or more metallic poles, embedded in non-conducting masonry. Siemens' historical furnace (1880), a furnace of Borchers and various constructions of Girod belong to this general type.

Another method is to make a uniformly conducting hearth by use of a rammed conducting lining, as has been done by the Firming Steel Works (French patent, 387,747, March 4, 1908). Here the hearth is formed of a refractory mixture rendered conducting by the introduction of carbon, or carboniferous mate-

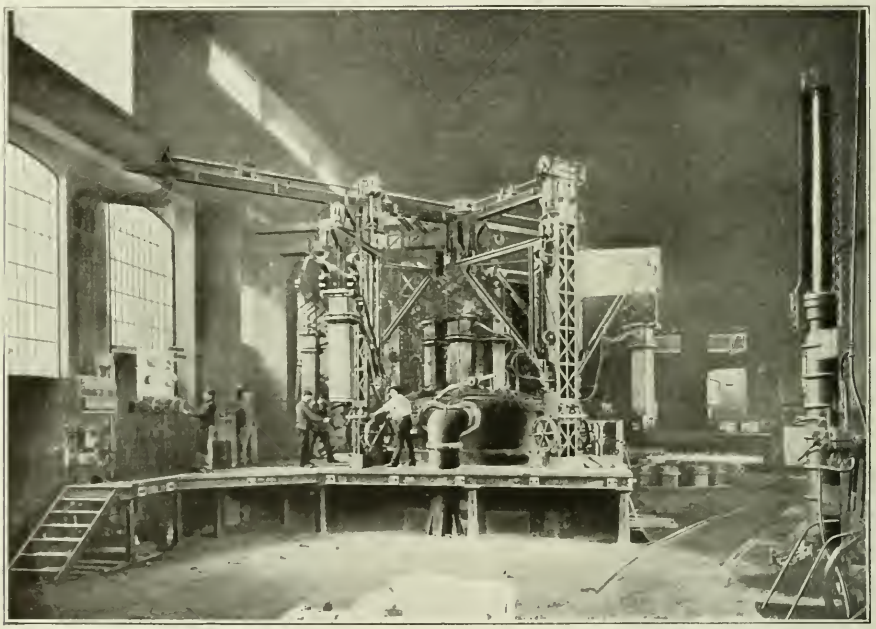
rial (tar pitch), into the refractory material (magnesia, silica, etc.).

The carbon content of the material is progressively raised at different levels in the depth of the hearth, so as to utilize at the beginning of a run the variations in electrical conductivity of the rammed mixture, according to their content of carbon material. The upper layer of the lining mixture which comes into contact with the steel is formed of a mixture quite low in carbon, so as not to influence the carbon content of the steel.

According to the inventors, the crucible having once been heated becomes permanently conducting, no matter what the variations of temperature of the furnace; consequently restarting from the cold state becomes practically possible. The very easy, because it is uniformly conducting throughout its entire transverse section, by reason of the iron bars near together.

The mechanical resistance of the hearth to penetration by the bath is very considerable, and no deterioration by lifting of the bottom, splits or fissures is to be feared. Finally, the mechanical joining of the bars at their lower ends, and their intimate union by the pisé make the bottom block of the furnace absolutely undeformable.

This conducting hearth block constitutes the original portion of the furnace, of which the working chamber is formed as ordinarily by a metallic structure lined with basic refractories strongly fastened and braced. The chamber is enlarged above



KELLER FURNACE PLANT.

Firming Steel Works, where this furnace was invented, have, however, constructed up to the present time only one furnace of small capacity.

Mr. Keller then describes his own bottom construction, which he characterizes as a "compound conducting hearth." This requires no masonry whatever.

The conducting hearth is composed of electrically reinforced pisé (pisé armé) made as follows:

Iron bars 1 in. to 1¼ in. diameter, regularly spaced about 1 in. to 1¼ in. apart, are placed vertically and made firm to a metallic plate at the bottom, so as to form a group completely filling the furnace bottom, upon which will rest the liquid metal. A pisé consisting of magnesia is strongly rammed while hot between each group of four adjacent bars, which thus form by reason of their mechanical strength, a sort of mold, permitting considerable compression of the mixture introduced. The pisé thus formed must be driven home by means of a suitable [illegible].

In this compact mass or block the metallic sections are good conductors when cold, when heated, the pisé also becomes rapidly conducting. The whole is surrounded by a metallic casing cooled by a current of water. The lower plate fastened to these iron bars is connected to one of the poles of the source of electric supply.

This conducting hearth makes the starting up of the furnace the hearth for better support of the hearth block. The pisé is easily repaired through the charging doors, after tapping, when necessary.

The body of the furnace is cooled on its entire periphery at the upper level of the hearth, to insure protection at the junction of the lining of the working chamber with the hearth.

The furnace is closed by a cover, through which the electrode passes. The regulation of the electrode is accomplished either by hand or automatically; the latter is more simple and preferable.

To avoid shut-downs, when replacing an electrode, the latter is placed at the end of a swinging arm, so that it may be removed out of the way, and replaced by another electrode all ready at the end of a similar swinging arm; the changing of an electrode is thus accomplished in two to three minutes.

There may be only one electrode at the top; this is then in series with the hearth. Or there may be several electrodes at the top, all in parallel with each other and all in series with the hearth. Or there may be several electrodes at the top; for instance, three, connected to the three phases of a three-phase system, while the hearth forms the neutral point.

The hearth of a furnace of 3300-lb. capacity, especially dismantled for inspection and study, after several months' service, was in absolutely as good condition as on the first day, the

pisé having acquired an extraordinary hardness, comparable to rock, so that a drill was blunted.

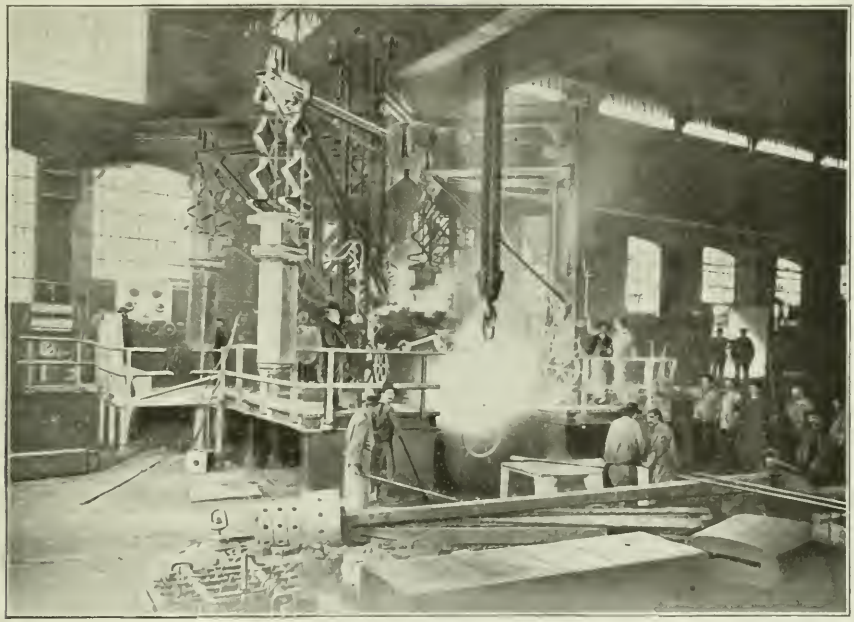
* * *

In the second part of his paper, Mr. Keller compared **series** and **parallel** connection of the upper electrodes. If the upper electrodes are **in series**, as in the Héroult furnace, the current passes from one electrode in form of an arc to the slag, passes through the slag, and passes again in form of an arc from the slag into the other electrode. Mr. Keller calls this "surface electric heating." If the upper electrodes are **in parallel**, the current passes in the form of an arc from them into the slag and downwards through the steel bath and leaves the furnace through the conducting hearth. Mr. Keller speaks of this system as complete "electrification of the mass of molten steel."

Mr. Keller claims the following advantages for the parallel system, especially for furnaces of low or medium capacity: high magnetic permeability, such as wrought iron, cast iron or steel, inside the inductive loop.

However, while Mr. Keller recognizes that the electric furnace with a conducting hearth necessitates greater precautions in its practical design and construction than the furnace with electrodes in series, yet he thinks that the engineer who is thoroughly familiar with alternating currents will know how to get around and avoid the difficulties which the problem presents, and even in a furnace of very large capacity may obtain a reasonable power factor. This is more particularly true if the engineer is allowed to design the whole electro-metallurgical installation, for under such circumstances he will not fail to adopt a low-frequency (20 periods, for example), which will greatly simplify the design on account of the reduction in the inductance of the circuit.

According to Mr. Keller, with a frequency of 20 periods a 1600-kw furnace may have a power factor of 0.9 and a capacity



KELLER FURNACE PLANT.

Greater homogeneity of the metal produced; greater simplicity of starting and operation when used for the treatment of a cold charge; greater ease of preserving the roof of the furnace.

On the other hand, the parallel system has the following disadvantages: There are electrical fittings at the lower part of the furnace, while there are none with the series system. Further, in the furnace, with two upper electrodes in series and with an equal rate of generation of energy, the current density is only one-half that in the furnace with the conducting hearth, which means conductors of larger size for the parallel system. Further, the furnace with the conducting hearth necessitates a pretty large inductive loop, which contains the body of the furnace itself, while this is outside the magnetic field in the case of furnaces having electrodes in series. Finally, the power factor may be quite low if special precautions are not taken. It is necessary to resort to the construction of non-magnetic gaps in the furnace body, and its fittings; and in addition great care must be taken to avoid the use of fittings made of a metal of

of 10 to 12 tons for molten steel refining and finishing. He thinks the whole practical problem is the design of a durable non-carbon hearth and this he thinks, he has solved.

* * *

While Mr. Keller now appears to favor a furnace construction with parallel-connection of the upper electrodes and with the compound hearth of his own design, he has formerly used for a number of years furnaces with series connection of the upper electrodes. A summary of his experience with the series system is given in the third part of his paper.

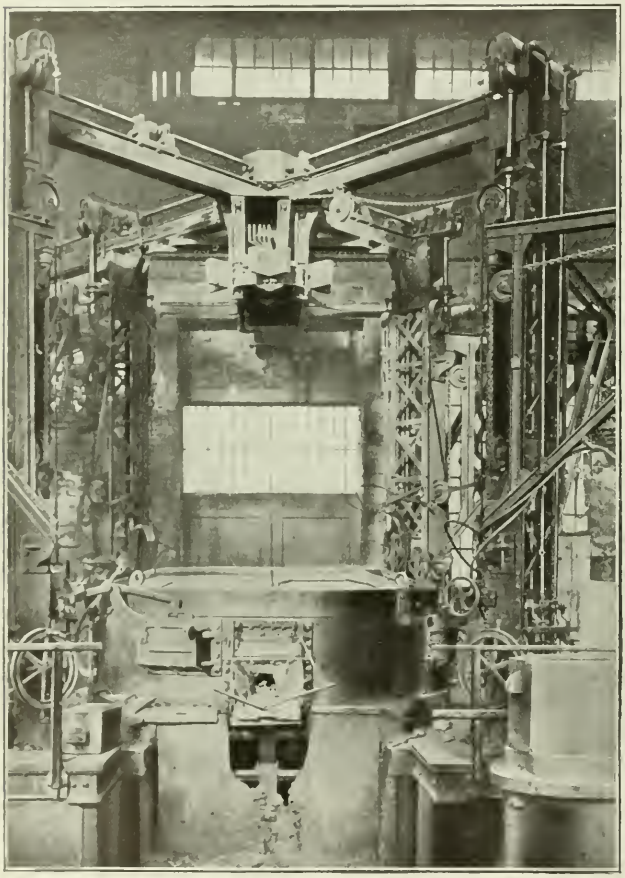
He first gives a review of his early experiments at the Kerrousse Works (Morbihan, France). This installation was described and illustrated in an article by Ch. Bertolus and P. McN. Bennie, in our Vol. I, p. 163 (January, 1903).

Mr. Keller then experimented at the Keller-Leleux Works in Livet, Isere, with a 550-lb. furnace with two electrodes. As the result of these experiments an 8-ton to 10-ton furnace was installed in 1905 at the Uricux Steel Works of J. Holtzer &

Company (Loire, France), the object being to finish, in an electric furnace, molten steel from an open hearth.

The electric furnace of the J. Holtzer Steel Works has four vertical movable electrodes, connected to the two poles. Each electrode forms at its base a heating zone in which the temperature can be regulated. Each pole carries two electrodes in parallel.

The movable furnace body is a self-contained crucible without any electrical connection whatever. The electrodes are suspended from rotable electrode supports in electrical connection



KELLER FURNACE PLANT.

with a central block or tablet for distribution of the current. These supports are entirely independent of the furnace body, and when they are all turned outward the cover of the furnace may be easily lifted or removed.

Then there is an overhead system of busbars for distribution of current, with fixed laterals for the movable connections to the revolving electrode brackets; and finally the switchboard for the electrodes, with suitable arrangements for control from a distance, and the measuring instruments.

Hydraulic power is used for the movement of the electrodes and the following combinations can be made:

(1) Simultaneous raising of two electrodes of the same polarity or of the four electrodes together.

(2) Simultaneous raising of two electrodes of the same polarity and simultaneous lowering of two electrodes on the other pole.

(3) Raising of one electrode and simultaneous lowering of the other electrode of same polarity.

(4) Separate movement of any electrode.

The regulation of the electric circuits is obtained very simply in the following manner:

(a) Regulation of Voltage: If there is simply an inequality of voltage between the two poles, the two electrodes on each pole are simultaneously moved up and down with respect to each other. This is done by operating valves on the hydraulic equipment.

(b) Regulation of Amperage: The amperage is equally divided between the four electrodes by means of their separate movement; if there is simply an inequality of amperage between two electrodes of the same polarity, there is a simultaneous and inverse movement of these two electrodes. Thus also by a single maneuvre the amperage is balanced between the electrodes.

It is very easy to replace an electrode. When the rotating arms carrying the electrodes are turned outwardly, the furnace body is entirely free of overhead encumbrances. The control connection block, which is placed high and out of the way, does not interfere with the lifting of the cover, the latter being rapidly done by means of the traveling crane which passes over the furnace. In this way any cover requiring repairs may be easily replaced by a spare one; furthermore, the cover being lifted, repairs to the chamber itself are very easily made.

The overhead central distributing system having radiation branches placed directly above the electrodes gives such a low self-induction that tests made at the J. Holtzer Steel Works have shown that the value of the power factor was about 0.97 with a current of 12,000 amp.

To avoid any possible chance of short-circuits between the two poles in the movement of the electrodes the following arrangement is used. Very thin flexible bars, of ½ mm thickness, for example, are attached at one end with the fixed conductors connected to the central busbar system, and with the electrode support. These flexible bars are divided into two sets expanded and brought together again at several points in their length, where they are securely fastened. There is thus formed a series of flexible rings which contract and enlarge according to the position of the electrode. Where the bars are fastened together to complete each circle, they are fitted with small rings which slide up and down on cylindrical rods, thus acting as a guide and adjusting position.

During working the gases generated in the interior of the chamber create a slight pressure; this condition is imperative to avoid all entrance of air which would destroy the reducing character of the furnace atmosphere.

At the Unieux Works of J. Holtzer Steel Company steel is made in an open hearth, poured into a ladle and then immediately fed into the electric furnace. The refining may be carried to 0.01 per cent and 0.01 per cent P; regular practice gives S and P = 0.015 to 0.02 per cent.

The period of treatment varies, of course, with the quality of steel desired. As an example of regular practice the following results are quoted:

Weight of charge put into electric furnace, 7500 kgs.
Mean power during operation, 750 kw.
Period of working, 2 hours 45 minutes.
Composition of molten charge:

C	0.15	per cent
S	0.06	"
P	0.007	"

Carbon content sought, 0.45 to 0.50 per cent.

Analysis of product: C 0.443 per cent, S 0.009 per cent, P 0.008 per cent.

Energy consumed per ton, 275 kw-hours.

Electrode consumption, 18 mm per hour for four electrodes having a cross-section of 400 mm x 400 mm.

For continuous working and assuming the cost of electrodes to be 35 francs per 100 kgs. this corresponds to a cost of about 4 francs (80 cents) per ton of steel.

The labor on the furnace, including feeding of the necessary materials, was provided by three laborers and one melter.

The regulation was manual and attended to by one of the three laborers, who looked after the repair of the furnace and the connection of the electrodes. But the regulation could be carried on just as well by automatic regulators.

Mr. Keller thinks that the electrode furnace should find its principal place in metallurgy in the direct application of three-phase currents, since many steel works already use three-phase currents for power purposes. The electrodes may be connected in delta or star. In the latter case the furnace hearth is made the neutral point. According to Mr. Keller it is now possible to approach without fear the construction of a three-phase furnace having a capacity of 20 tons; this furnace would necessitate the use of about 1800 kw; such a furnace would be capable of purifying 250 to 300 tons per day of ordinary basic converter steel in a series of heats which would last about 1½ hours each, and which would bring the sulphur content of the molten steel from the converter from 0.08 to 0.02 per cent approximately, at the same time permitting the deoxidation and decarbonization as required.

The cost of work of this kind would vary from 15 to 20 francs per ton of steel treated, calculating electric energy at 0.015 francs (0.3 cent) per kw-hour, a price which is possible with gas engines supplied from blast furnaces if no charge is made for the gas, and estimating the other factors of cost at a price corresponding to their usual value.

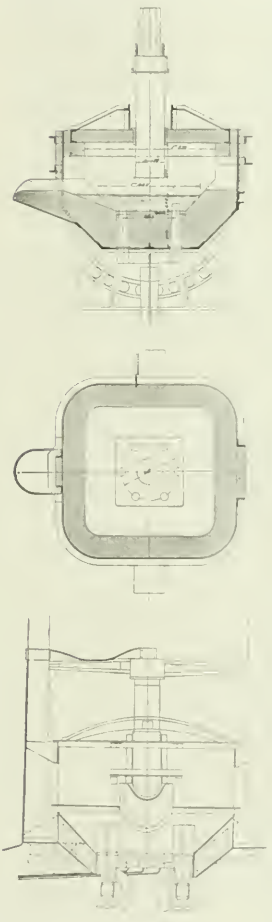
The passage of steel through the electric furnace, where under the influence of superheating, it would be subjected immediately, and by a rapid process, to a marked desulphurization, would permit the use in the converter of a cast iron richer in sulphur. This advantage would enable a metallurgical plant, taking advantage of this circumstance, to use ores which otherwise would have been rejected, and thus the introduction of the electric furnace in such works would have a two-fold and important economic application.

Girod Electric Steel Furnace.

A description of his electric steel furnace was the subject of a paper by Mr. PAUL GIROD, managing director of the Société Anonyme Electrometallurgique Procédés Paul Girod, Ugine, France. This furnace has already been described before in our Vol. VI, pages 428 and 516, and our Vol. VII, page 9.

The working portion, or hearth, of the Girod furnace consists of a circular or oblong chamber filled with molten metal to a depth of 25 to 30 cm (12 to 14 inches). One or more electrodes of like polarity are suspended above the bath; the other pole or terminal consists of a number of pieces of soft steel buried in the refractory material of the hearth at its periphery, the upper ends of which come into contact with the metallic bath. The electric current forms an arc between the upper electrode and the surface of the bath, through which it passes to the connecting pieces of soft steel to the other terminal.

The upper portions of these connecting pieces directly in contact with the metallic bath naturally fuse to a certain depth. This does not, however, exceed two to four inches, as has been demonstrated by sections made of these pieces after several months' use. In order to decrease the depth of the used portion as much as possible, and to assist in preserving the lower portion of the refractory lining of the furnace, the lower extremities of the connecting pieces are fitted with a water-cooling arrangement in a cavity about 6 in. deep in that portion of the steel connectors projecting outside of the furnace; this also serves for connecting the cable to this terminal.



GIROD FURNACE.

If a number of electrodes are used above the bath they are all in parallel. The furnace may be run with either continuous or alternating current, but in the latter case it is necessary to take into account that the power factor will be about 0.88.

The furnace chamber is a metallic shell made of plate steel, lined with magnesite or dolomite.

A cover lined with silica brick is mounted over the furnace, the ports for the electrodes being fitted with a removable cast-iron water-cooled frame.

The electrodes are so fitted that air cannot enter the furnace. This and the use of metallic frames or collars is rendered possible by the fact that the electrodes have the same polarity, and there is, therefore, no danger of short circuits across the cover. The use of metallic frames for the electrode ports is not altogether necessary, but has the advantage of more perfectly closing the furnace and stiffening the cover.

A great advantage of this type of furnace is the perfect ease with which it may be started up with cold charge. As there is only one drop of potential at the top, regulation is easy. On account of the low voltage of the furnace (55 volts) perfect insulation is easier than with double the voltage.

The following data has been taken from Girod furnaces in actual operation at Ugine, in the works of the Compagnie des Forges et Acieries Electriques Paul Girod.

One of these furnaces has now been working for several years and has never given the slightest trouble.

The raw materials at Ugine consists of scrap, turnings and some cast iron, gathered indiscriminately in the market. The problem, therefore, is to refine these materials, charged cold, to obtain a high-grade steel.

The average analysis of raw materials is 0.4 to 0.5 C, 0.15 to 0.25 Si, 0.5 to 0.7 Mn, 0.06 to 0.09 S, and 0.08 to 0.10 P. The finished steels are of any desired grade, of all degrees of

hardness, carbon and special structural steels, tool steels, cast steels, etc.

From the physical tests of the steels produced Mr. Girod claims their characteristic features to be a high elastic limit and great resistance to shock. "Compared to Bessemer, open-hearth or crucible steels, these qualities seem due to the chemical purity of electric furnace steel, to its homogeneity and freedom from occluded gases. The two latter points are of greater importance inasmuch as the sulphur and phosphorus content hardly ever exceeds 0.030 per cent anyhow."

The average energy consumption for fusing, refining and finishing a charge of cold scrap is 900 kw-hours in a 2-ton furnace and 700 kw-hours in a furnace holding 8 tons to 12 tons, the energy being measured at the furnace terminals. These figures will, of course, be slightly increased in the case of special steels, or diminished as the refining period is shortened.

The electrode consumption is about 16 kg to 18 kg (35 lb. to 40 lb.) in a 2 ton furnace, and 13 kg to 15 kg (29 lb. to 33 lb.) in an 8-ton to 12-ton furnace per ton of steel produced. The unused portions of the electrodes, corresponding in length to the height of the arched cover above the bath, are included as having been actually consumed. This refers to ordinary amorphous carbon electrodes, made from retort carbon and not graphitized.

The lining is of brick (or better still a paste) made of magnesite or dolomite. These materials give equally good results, and, therefore, the one is used which can be had at the lowest price. In France, the dolomite is generally used, as the price is very much lower than magnesite.

One such lining will last 40 to 50 heats without any repairs, after which the lateral walls of the furnace receive partial repairs. Now and then, generally after 100 heats, the upper portion of the hearth lining for a distance of about 10 cm (4 in.) is repaired also; after having scraped and cleaned the hearth, magnesite or dolomite is rammed in for a height of about 10 cm, taking care to preserve the passage for the metallic contact pieces.

The hearth otherwise does not require any other repairs than fixing up the sides for the distance of 10 cm. Thus, in the oldest furnace in use at Ugine the same hearth has been in place for over two years without having necessitated repairs.

The cover is of silica or high-grade firebrick, the life depending upon the quality of the brick; with good material a cover will last through 40 to 50 heats. Under these conditions, in France, the expense for furnace linings will be 7 to 8 francs ($1.40 to $1.60) per ton of steel produced in a small furnace, and 4 to 5 francs (80 cents to $1) in a large furnace of 8 to 12 tons capacity.

To handle the furnace three men are sufficient: a melter, an assistant melter, and a boy for a small furnace, four men for a large furnace. At Ugine the large furnaces are charged by an electric charging machine.

To the expenses above mentioned should be added the sundry additions, such as lime, ore and fluorspar, for the various slags, on one hand, and ferroalloys, ferromanganese, ferrosilicon, silico-manganese, etc., added during the final period and finishing off the metal, on the other hand.

The loss in the furnace will depend mostly upon the composition and state of oxidation of the scrap and materials charged; with heavy scrap, but little oxidized, the loss is from 6 to 7 per cent.

In the case of simply smelting a charge of cold scrap (selected and sufficiently pure not to require refining), the time of the heat is diminished by 25 per cent and the various above expenses of melting are reduced to 75 per cent of the above values.

If the electric furnace process consists of treatment of molten steel from the converter or open-hearth, the time of the heat is reduced to 20 or 30 per cent of the length of a heat required with cold charges, and the various factors entering into the cost are brought to 20 or 30 per cent of the above values. The energy consumption, the carbon consumption and repair costs of the furnace are very much reduced by the fact that the furnace is kept constantly hot, there being no important drops in temperature as in the case of cold charging, a condition unfavorable both from the point of view of energy consumption and preservation of lining.

Mr. Girod then gives a review of the various Girod furnaces in commercial operation (see our Vol. VI, p. 469 and Vol. VII, p. 9) and tables of the different steels made at the Girod works.

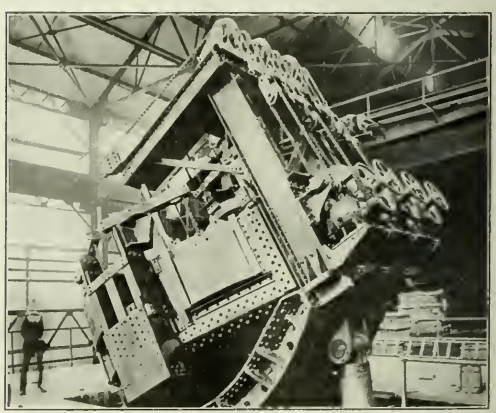
PAUL HÉROULT.

They range from extra soft to hard (0.08 to 0.06 C.), the sulphur being from 0.010 to 0.017, and the phosphorus from 0.005 to 0.012; also five grades of nickel steel and nickel-chrome steel (the composition of the latter being 0.420 C, 0.199 Si, 0.500 Mn, 0.010 S, 0.009 P, 0.77 Cr, 2.53 Ni). The Girod works also produce various kinds of tool steels.

Mr. Girod finally gives a table showing the results of mechanical tests of his steels to substantiate his claims mentioned above.

Heroult Electric Steel Furnace.

Mr. Robert Turnbull, resident engineer in America for Dr. Paul Héroult, presented a paper in which he first outlined the



TILTING 15-TON HÉROULT FURNACE AT SOUTH CHICAGO.

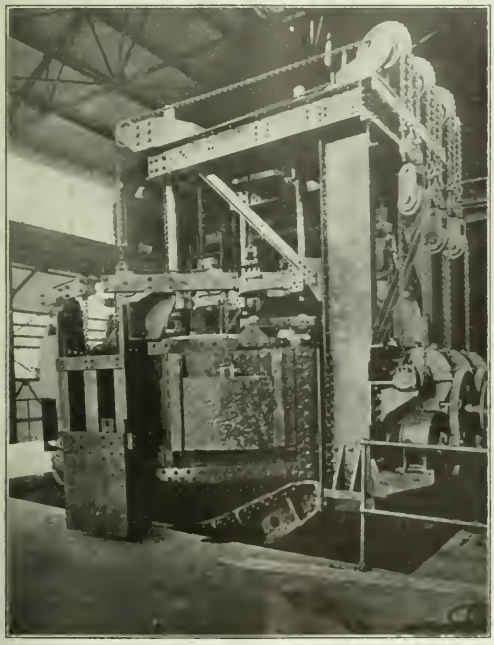
reasons why Dr. Héroult decided to adopt his particular type of furnace.

In his aluminium process patented in 1887, Héroult employs a furnace of the crucible or pot type, consisting of a metallic

casing, the bottom of which was carbon lined forming one pole, while the movable carbon or electrode dipping into the charge to be reduced and melted formed the other pole. This furnace was the basis of his work on special alloys, such as aluminium-bronze and silicon bronze, etc.

Later when the problem came up of producing low-carbon ferrochrome, he had to abandon the carbon bottom and find another construction. His first attempt in this direction was to use a bottom lined with chromite, with a carbon rod in the center forming the lower pole of the furnace. His idea was that part of the carbon would be taken up by the metal and would be replaced by the metal itself, this process going on until the metal reached a sufficient depth where, owing to the outside radiation, it would freeze and remain in this state, thus forming the passage for the current and preventing the contact of the carbon with the molten metal.

This scheme, although giving certain results, was soon abandoned, and after some months of experimenting the present furnace was invented. The advent of low-carbon ferrochrome brought with it the possibilities of producing other soft metals, and it was not long before Dr. Héroult was at work on the steel



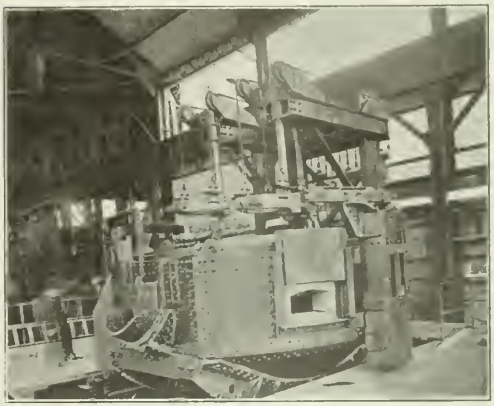
REAR VIEW OF 15 TON HÉROULT FURNACE AT SOUTH CHICAGO.

problem, and as he already had his furnace the production of steel became very soon an accomplished fact.

The main points which Dr. Héroult claims for his furnace are the following:

First—The total absence of electrical parts in the furnace proper, it being nothing else but a modified open hearth with the heat introduced above the metal by the electric current in place of gas. This in itself is an important factor, as it does away with the bottom pole, considered by Héroult to be always the cause of much trouble in electric furnace work, and allows of any patching necessary to the bottom or sides, without interfering with the work of the furnace.

Second—The heat being introduced by means of two electrodes working in series, the current passing through the bath from one electrode to another and vice versa, necessitates carrying only one-half the current that would be the case should the current flow from one electrode through the bath and then through the bottom of the furnace if the power is the same in both cases. Thus all conductors are reduced to one-half the section required in the other case, and the electrodes can perform more efficient work owing to the lesser density of current to be carried.



SIDE VIEW OF 15-TON HÉROULT FURNACE AT SOUTH CHICAGO.

Third—The possibility of refining impure metals and transforming them into the finest grade of tool steel. The heat being generated in the slag and not in the metal itself makes the slag the hottest part of the furnace, and all impurities can be removed by the use of special slags. This allows the use in the Héroult furnace of the poorest kind of scrap high in sulphur and phosphorus, both these impurities being removed at small cost.

Mr. Turnbull then gives examples from practice at La Praz of the refining possibilities of the Héroult furnace (see data of a complete month's results in our Vol. VI, p. 226).

The number of kw-hours necessary in the Héroult furnace to melt and partially refine one ton of steel is 600, 100 more being necessary for the finishing slag, making 700 in all. Those figures are for a five-ton furnace and starting on cold scrap; in the case of a 15-ton furnace they would be considerably reduced. Should the metal be charged hot into the furnace, that is to say, in a molten condition, and no other work be demanded outside the recarbonizing, desulphurizing and deoxidation of the steel, from 140 to 160 kw-hours are necessary in the five-ton furnace: for a 15-ton furnace this will probably be cut down to 100 kw hours.

The life of the electrodes depends on the conditions under which the furnace is run; in cold melting and continuous work the consumption is from 60 lb. to 65 lb. per ton of steel, but in cases where the metal is charged in the molten state this consumption would only be from 10 lb. to 15 lb. per ton, those figures including the part of the electrode which cannot be utilized.

The life of the lining depends entirely on the care with which the furnace is run; some linings will last for a year without being replaced, while others may have to be changed in three months. In this type of furnace a lining ought to last almost indefinitely, as it is exposed at no time to silicious slags and can be repaired after each heat by simply throwing in magnesite or dolomite as the case may be. The repairs are small: what suffers most is the roof, which has generally to be renewed once a month; as, however, a spare roof is always on hand, this can be done in a few hours.

As regards the best kind of lining for a furnace of the

Heroult type, good magnesite mixed with basic slag and using tar for a binder is about the best; burnt dolomite can also be used with good results. There is no mystery about this; any one who can make a good bottom in a basic open hearth can do the same in a Héroult furnace.

Mr. Turnbull finally referred to the adoption of the Héroult furnace by the United States Steel Corporation. As was mentioned before in this journal, two furnaces, each of 15 tons, are built at present; that at South Chicago was to be started on the day when the paper was presented, that at Worcester in July.

The steel to be treated at the South Chicago works will be brought direct from the Bessemers and two refining slags will be used in the electric furnace; the first an oxidizing slag to take out the phosphorus, the second a deoxidizing slag for the removal of sulphur and the gases.

The furnace is three-phase, the power being supplied by three transformers of 750-kw capacity each. It is expected to turn out 16 heats a day, or about 240 tons of steel. The electrodes, of which there are three, are the largest which have so far been built in one solid block, being 2 ft. in diameter by 10 ft. long and weighing something over 3200 lb. The current density will be about 28 amperes to the square inch, a figure which is considered a little high for the work, 25 being ordinary practice.

As to the maximum size of furnace which it is now possible to construct, it is the intention to build them up to 30 tons capacity. Very much will depend, however, on the work which has to be accomplished, that is to say, whether one or two slags would be used. In case of one slag Mr. Turnbull is sure that a 30-ton furnace is possible, but should two slags be used, owing to the difficulties which might be encountered in raking off the first slag, it may be found that a 15-ton capacity is nearing the limit. It could certainly be worked quicker than one of a 30-ton capacity.

In conclusion, on Dr Heroult's authority, Mr. Turnbull extended a cordial invitation to all interested to visit the Héroult works at La Praz, France, where a careful study of his furnace and process can be made. "We have no secrets to conceal, the work is done openly and the operations can be conducted and controlled by the interested parties themselves, with the aid of our operators, and without any limit as to the duration of such operations."

Discussion.

The discussion was opened by an excellent speech of Dr. John A. Mathews, of the Halcomb Steel Company, of Syracuse, the pioneer electric steel plant of this country, where the Héroult process is in operation (see description in our Vol. V, p. 272). Dr. Mathews first criticized various general statements often made by electrometallurgists as not having been sufficiently substantiated by actual experimental data, though they may be substantially true. For instance, it is generally assumed or claimed for each electrical process that the superiority of its product depends upon the fact that the steel is melted in a neutral or reducing atmosphere and hence the product is better deoxidized and freer from dissolved gases. While this sounds reasonable and is probably true in most cases, no experimental proof or determinations of the gaseous content of electric steel have ever been given.

"As scientific men, I ask you whether it would not be a good idea to make an exhaustive investigation of this subject, and while we are about it make it equally exhaustive in regard to the gaseous impurities of steel made by the old processes. Would not an authoritative investigation of the subject be of tremendous interest and might not its results be of inestimable practical importance? Surely the desultory investigations that have been made of this subject for years past have been far from satisfactory and even the methods of determination are not above suspicion as to their accuracy. Moreover, the influence of the casting and subsequent heats has not been studied in its relation to the gaseous contents and mechanical properties.

"To my mind, an isolated test or two of the specimens of steel taken at random, said to be Bessemer, open-hearth or crucible, is of no value whatever. The whole history of the process by which it was made must be recorded. Such an investigation cannot be taken lightly; it will take years to complete; its outcome will be problematical, but is it not high time that it were begun? I have been pondering this subject in my mind for years, and am trying to develop a plan to undertake it. It is such a stupendous task that it cannot be done at odd times or in a college laboratory. Several workers must give their undivided attention to it for years. Are we ready for it? Would this society support me in the organization and direction of such a work? It ought to be undertaken under works conditions where the material can be watched from the beginning. As manager of a works where three distinct processes are in use, the basic open-hearth, the crucible and the electric, I feel it a solemn duty to undertake it."

DR. EAKELAND IN CENTER, MAJOR STASSANO AT THE RIGHT, DR. KATSURA AT THE LEFT.

As to electrical steel, Dr. Mathews believed that there was hardly room for reasonable doubts that several electrical processes are capable of producing steel fully equal to that of the older processes. To be sure there are still those who believe that good tool steel can only be made by various blends of Swedish irons; who claim that the results of melting hammered Swedish bars are much superior to those obtained by melting rolled bars of the same material; who talk wisely about "body" in tool steel, but who never define what "body" is. They remind one of a student who, when called upon to define space, said, "I can't exactly define space, professor, but I have it in my head."

Now, while it is true, that there seems to be an intangible something about tool steels which is not revealed by the ordinary analysis, yet the weak point in this talk about "body" is that it seems invariably to be developed in an astonishing degree in the particular brand of steel which the spokesman is

trying to sell. To Dr. Mathews' mind, "body" is more likely to represent the embodiment of the sum total of care used not only in the selection of raw materials, but also in the melting, cogging, rolling and annealing of the steel and in the selection of the right analysis for a given purpose.

Dr. Matthews then spoke of the relation of the electric furnace to the tool-steel industry. Naturally the original induction-furnace process as a simple melting operation had first appealed to him, but, on second thought, the question suggested itself: Why not use the electric furnace also for refining?

"One cannot wax enthusiastic in contemplation of a pile of muck bars—the crudest of all crude material in the steel industry. And yet, remelted in crucibles, they yield a product of great merit. The irregularity in composition of the product is objectionable, but this difficulty may be lessened by the use of Swedish bar iron, which is a reworked iron, much freer from entangled slag and more uniform in composition. In this country the use of Swedish iron is fast passing away; the crucible-steel industry of this country, with very few exceptions, is a mere business—not an art, as abroad. In the writer's works a Swedish iron is used which costs more in the bar than the finished product of some crucible mills sells for. They retain tenaciously the best traditions of English crucible-steel practice and methods, but they are not standing still.

"We have the first commercial electric furnace that was built in the Western Hemisphere. We are making steel in it, and good steel, too. To the best of my knowledge and belief it is chemically superior, and physically and mechanically superior to most, and equal to any, crucible steel made. I say this not boastingly, but as a scientific man addressing scientific men. Other electrical processes may produce as good steel, but I doubt whether the product of any gas or coke fuel furnace, no matter how choice the raw materials used, can more than equal it. I believe I am stating the case conservatively when I say that this product is as good as the best and all laboratory and practical tests of the product to date seem to point to this conclusion.

"But this was not always so. Some steel was made in our furnace in the early days that was not what it should have been. The electric furnace is a new thing; you must develop a practice with it as with other processes. It is not an automatic machine; we experienced trouble with it; it required care and study and practice. If one wishes to start a new open-hearth plant skilled men can easily be had; but if one starts an electric process, where will he look for experienced men? Unlike poets, they are not born, but made, and the making is not without expense, anxiety and some failures."

To one contemplating the installation of an electric furnace the choice of process depends upon many things—the material to be produced and the materials from which it is to be produced; the location; the source of power, whether bought or manufactured. It would appear that so far as types of furnaces and processes are concerned that we are now fairly well supplied; attention now must be devoted upon the part of inventors to improving the furnace design, the lining materials, the electrodes, if used, the power factor and thermal efficiency and thermal control. The user must develop his own works' practice, just as in past generations our predecessors had to do when the Siemens producer, gas-fired curcible furnace, graphite pots, acid Bessemer, acid Siemens-Martin, and later basic processes were new things and were looked upon with suspicion by many a good metallurgist.

Besides these remarks of Dr. Mathews there was very little further discussion. While practically every steel company in the United States was represented, their representatives preferred to remain silent.

To supplement Mr. Girod's paper reported above, Dr. Richards read a later communication from Mr. Girod giving some details of their method of deoxidation.

They never use metallic aluminium as a deoxidizing agent, but always alloys, for instance, 20 per cent Mn, 20 Si, 12 Al, the balance being iron. Another alloy contains 40 to 60 Si, 20 to 30 Al. Silicon is added preferably in form of high-grade ferrosilicon, 50 to 90 per cent. For making silicon steel they use 25 to 30 per cent ferrosilicon.

Mr. Girod also stated that he had observed that steel finished in the electric furnace from molten steel from the converter or open-hearth did not seem to be as good as steel made in the electric furnace from a cold charge. Though the steel may be apparently of the same chemical composition, the physical properties are different. He could not give any exact reason, but it seems to him that the steel absorbs in the converter or open-hearth small amounts of certain elements which are not easily eliminated afterward. He prefers to make special tool steels from a cold charge in the electric furnace. The complete electrical treatment is more expensive, but, in Mr. Girod's opinion, it leads to better results.

LOUIS SIMPSON.

As to the claim made in Mr. Turnbull's paper that a water-cooled bottom pole is always a trouble, Dr. Richards said that he had seen the Girod furnace and there was not any trouble to be found with its bottom after a whole year's working; the water-cooling is only on the outside.

Thursday Afternoon Session.

The afternoon session was opened with an address by Mr. LOUIS SIMPSON, of Ottawa, Canada. Although Mr. Simpson's name has not often appeared in print (except as author of an occasional article like that in our Vol. II, p. 421), those who have followed closely the development of the electrometallurgy of iron and steel in recent years know that Mr. Simpson has been one of the most energetic driving forces in this movement and has been preëminently active in arousing the interest which now exists in Canada in this new industry. He recently resigned as general manager of the Montreal Cotton Company in Valleyfield in order to devote all his time to the promotion of an electric iron and steel industry in Canada.

Mr. Simpson spoke in his characteristic manner of the special conditions in Canada which promise a commercial success for an electric iron and steel industry; good ores and cheap water-powers are available, and coal is expensive. He expressed the conviction that it would be found practicable to make nickel steel directly from ore in the electric furnace. He stated that there are quite a number of electric steel furnaces now working in Sheffield, while in continental Europe the development has gone still further.

Mr. Simpson sketched his plan of an electric iron industry in Canada. It includes a water-power development of 80,000 hp.

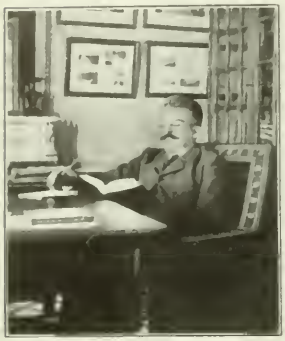
Mr. L. Simmons's optimistic speech was generously applauded.

Four papers of Mr. Gin were then presented in abstract by Dr. Richards, Mr. Lidbury, Mr. Saunders, and Mr. Bennie.

Silico-Vanadium.

A paper by Mr. Gustave Gin, of Paris, states that he has obtained the silicide SiV_2 by reducing in an electric furnace a mixture of vanadic acid, silica and coke according to the equation:

$$3\,V_2O_5 + SiO_2 + 13\,C = 2\,V_2O_2 + Si_2 + 13\,CO.$$



GUSTAVE GIN.

This amounts to approximately 10 parts of vanadic acid, one part of silica and one part of coke, by weight. Mr. Gin used a current density of 1200 watts per square inch of cross-section of the electrodes, but found that a notable amount of the vanadic acid was volatilized. The volatilization is very much reduced by using vanadium trioxide according to the equation:

$$3\,V_2O_3 + SiO_2 + 5\,C = 2\,V_2O_2 + SiV_2 + 5CO.$$

By using commercial raw material, Mr. Gin has obtained a silicide containing vanadium 71.10 per cent, iron 5.40 per cent, silicon 22.16 per cent, carbon 0.72 per cent.

The manufacture of the double silicide of iron and vanadium is more easily accomplished than that of the silicide of vanadium, when reducing vanadium trioxide by means of rich ferro-silicon. The brittle 60 per cent ferrosilicon is powdered and mixed intimately with vanadium trioxide. This is agglomerated with 4 to 6 per cent of coal-tar pitch and molded into briquets or oval balls, which are charged into a double-hearth furnace with a rammed magnesite bottom.

Reduction takes place according to the formula.

$$4\,V_2O_3 + 4\,FeSi_2 = 5\,C = Fe_4Si_8V_8 + V_2O_3 + 7\,SiO_2 + 5\,CO.$$

Mr. Gin has thus produced a silicide containing vanadium 45.04 per cent, iron 33.52 per cent, silicon 19.40 per cent, carbon 0.62 per cent.

Vanadium silicide, or the double silicide of iron and vanadium, may also be produced in the electric furnace by the reaction of trioxide or tetraoxide of vanadium with carborundum, or of a mixture of carborundum with rich ferrosilicon.

Vanadium.

A paper by Mr. Gustave Gin, of Paris France, deals with an electrolytic method of producing vanadium, using a principle analogous to that employed in the manufacture of aluminium. He uses vanadium trioxide as the solute in the electrolyte and calcium fluovanadate $VF_3\ 3\,CaF_2$ as the solvent. Carbon anodes are used.

The lining of the bath consists of pure electrically fused alumina agglomerated with tar and a little vanadic anhydride. When heated to a bright red, a strong and compact mass is obtained.

The cathode is formed by cone-shaped conductors of pulverized and agglomerated ferro-vanadium, which pass through the lining material and come out flush with its surface. At their lower parts these conductors are bedded in graphite resting upon a copper plate connected with the cable to the negative pole of the generator. The metal first deposits upon the upper ends of the cathode cones which become covered with solid sheets which continue to enlarge until they meet together.

The metal cannot be tapped since the necessary temperature would be above that of the volatilization of the bath. When a sufficient quantity of metal has been deposited the electrolytic bath is emptied and the metal allowed to cool. The bottom of the furnace is then removed and the plate of metal separated from the adhering cathode tips.

The best current density is 4.5 amp per square inch of anode section.

Low-Carbon Ferro-Alloys.

A paper by Dr. Gustave Gin, of Paris, France, refers to a method employed in some ferro-alloy works where low-carbon ferro-alloys are made in two steps. First, the mineral is reduced by carbon and a ferro-alloy, relatively high in carbon, is produced. The accumulated slag is then removed and ore is placed upon the surface of the high-carbon metal so as to oxidize gradually the carbon contained in the ferro-alloy.

It is generally admitted that such decarburization requires a prolonged superheating, and it might seem that the decarburization becomes more easy and complete as the temperature of the bath is more elevated.

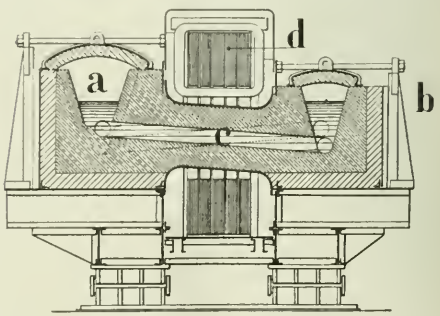
Mr. Gin thinks that the conditions are more complicated, since the carbon content is reduced not only by a superficial reaction between the metal and the fused slag in contact therewith, but also, and perhaps in larger measure, by an intermolecular reaction between the combined carbon and the oxide dissolved in the metal.

While it is probable that the amount of oxide dissolved in the fused iron bath increases with the temperature, it does not follow that the actual reaction between oxygen and carbon really takes place at the highest temperature. According to Mr. Gin this reaction really takes place during cooling and becomes strongest just before the fused bath becomes solidified. He refers to the fact that when ferro-chrome containing carbon is superheated in the presence of an oxidizing slag and when the entire mass is allowed to cool, it is regularly found that, on cooling down, the surface of the previously tranquil bath begins to boil, at first slightly, but the boiling increases more and more in intensity until immediately before solidification.

Mr. Gin thinks it likely that this ebullition is caused by the disengagement of oxide by carbon, due to deoxidation of the dissolved oxide by the carbon present in the alloy. This paper does not contain, however, an actual proof of this theory, though he refers to the opinion advanced by Le Chatelier that an increase of temperature favors endothermic reactions and a lowering of temperature exothermic reactions.

Self-Circulating Electric Furnaces.

A paper by Mr. Gustave Gin, of Paris, describes a method of producing automatic circulation in electric furnaces. The



SELF-CIRCULATING INDUCTION FURNACE.

method is first described as applied to the induction furnace.

The furnace has two principal receptacles *a* and *b* united by two heating canals *c*. The vessel *a* is larger than *b*, and is called the working bath; it carries a tap door for lag and an-

other for steel. The induction bobbins *d* surround the two heating conduits *c* and are cooled by forced ventilation. The whole furnace is mounted on an axle, so as to tilt it for running off slag and metal.

As is indicated in the illustration, one connecting channel *c* is inclined downward from left to right, the other (shown by dotted lines) from right to left. The circulation is produced simply by differences of specific gravity.

In the second part of the paper the same method of self-circulation is applied to an electrode furnace, and in the third part to a combined induction and electrode furnace.

Induction and Combination Furnaces.

A paper by Dr. F. A. KJELLIN was a full account of the development of the Kjellin and the Röchling-Rodenhauser electric furnaces. The first part of the paper, which was presented by

E. A. COLBY.

Mr. John Hay, of the Gröndal-Kjellin Company, dealt with the simple induction furnace as invented in 1887 by Mr. E. A. Colby in this country and independently reinvented 12 years later by Dr. Kjellin in Sweden.

At the Gysinge plant in Sweden, the induction furnace has been used for years for the production of high-class steel from cold scrap and cold pig iron. The raw materials being white Dannemora pig iron from Gysinge ore and Walloon bar ends. Owing to the rather high price of bar scrap they have in later years sometimes worked the furnaces with cold pig iron and very pure iron-ore briquets (made by the Gröndal briquetting process). According to their experience, the quality of the steel made from pure ore briquets is the same as when scrap is used.

The necessary theoretical power per ton of steel produced from cold pig iron and scrap is about 489 kw-hours. The furnace at Gysinge consumed about 800 kw-hours per ton when working with cold pig iron and scrap. When cold pig iron and iron-ore briquets were used the power consumption per ton of steel was increased about 50 per cent.

Some advantages of the induction furnace over the crucible furnace are as follows: In the induction furnace the steel can be better protected against injurious effects than even in the crucible. It allows tappings which are very large compared with the contents of a crucible, and the steel seems to be of even better quality than steel produced in crucibles from the same raw materials. Dr. Kjellin cites two striking examples. In one case it was found that a bar of electric steel, 1 in. square, with over 2 per cent of carbon, could be twisted cold so that it looked like a corkscrew. This could not be done with crucible steel of the same composition. In another case a tool-steel maker found that he could reproduce his tool steel in the induction furnace with less additions of silicon and manganese than was necessary in the crucible.

The only probable explanation Dr. Kjellin can think of is that the higher heat in the induction furnace expels a portion of the gases dissolved in the steel and perhaps also facilitates the removal of the combined oxygen, so that the deoxidation is more complete than that obtained in the crucible during that period of melting which the Sheffield steel makers call "killing."

A list of 14 induction furnaces is then given, of which two are no longer working. Their aggregate charge is 31,900 kg and their aggregate power 4030 kw.

The second part of the paper deals with the Röchling-Rodenhauser combination furnaces which was specially invented to refine molten steel from the Bessemer converter. For detailed descriptions see our April issue, p. 171, and our Vol. VI, pp. 10 and 458. The operation is as follows:

After tapping, fluid steel from the converters is poured into the furnace and suitable materials—burned limestone and mill-scale—for forming a dephosphorizing basic slag are added. When the reactions are ended this slag is taken off by tilting the furnace.

For making rails the phosphorus is brought down sufficiently low in one operation, but for making of the higher classes of steel the operation has to be repeated.

When the phosphorus is removed, the carbon in the steel (if carbon steel is made) is adjusted by adding pure carbon to the bath, and afterward a new basic slag is formed in order to remove the sulphur. This slag is also formed in order of burned lime, sometimes with the addition of fluxes, such as fluorspar.

One necessary condition for successful desulphurization is that the slag is free from iron, and therefore sometimes ferro-silicon is added in order to quicken the reduction of the iron in the slag.

The adjoining table gives all details regarding power, frequency, power factor, production and cost of plant for different sizes of three-phase combination furnaces:

					Tapping lbs.		Output per 24 hrs. lb.	
		Electric Data.			Cold charging.	Hot charging.	Cold charging.	Hot charging.
Contents, lbs.	Kw.	Volt.	Cyc.	Cos ϕ				
2,200	175	500	50	0.8	1,540	2,200	9,240	35,200
6,600	350	3,000	50	0.6	4,620	6,600	27,720	106,600
11,000	550	3,000	25	0.65	7,700	11,000	46,200	176,000
15,400	750	3,000	25	0.6	10,870	15,400	64,680	246,400

The weights given are calculated at six charges per 24 hours for cold melting and 16 charges for hot melting, whereas the

F. A. KJELLIN.

actual times are 3½ hours per cold charge and 1 hour and 20 minutes for hot charge.

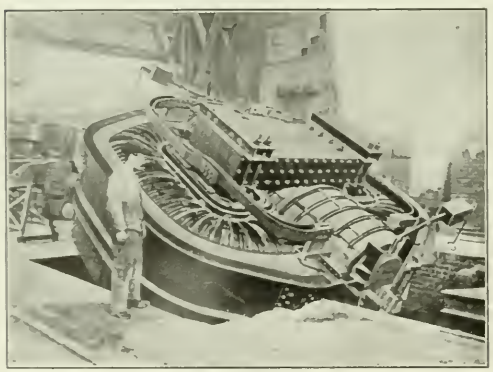
The voltage can be altered to suit circumstances, 12 per cent to be allowed for regulation

	P.	S.	Mn.	C.
Basic Bessemer steel charged into furnace having	0.08	0.08	0.5	0.1
Can be finished for rails, with 100 to 125 kw.-hours per ton, to	0.05	0.04	0.8	0.5
Or for quality steel, with 300 kw.-hours per ton, to	trace.	trace.	0.25	0.05

Open-Hearth Steel.—Martin steel which has been previously refined, dephosphorized and desulphurized, containing 1.22 carbon, 0.38 Mn and 0.209 Si, has been put into the electric furnace and allowed to remain there to remove gases, regulate the carbon and adjust the alloys, with an energy expenditure of 200,250 kw-hours per ton.

The costs of production are then given for a 2-ton, three-phase furnace producing steel for steel castings. The raw material is fluid steel from the converters. The power price is taken at 9 pfennig (2.18 cents) per kw-hour. The life of the lining is taken at 10 days, in which time 160 tons can be produced. The cost of operation, including the lining, power, wages and materials for the slag (but no charge being made for the converter steel itself) is $8.82. To this is to be added interest (5 per cent) and depreciation (10 per cent) of the plant, making a total of $9.23 per ton. For working the furnace three men are required. The time required for the removal of the lining is 24 hours.

In another table the production costs of a 7-ton, three-phase Rochling-Rodenhauser furnace are given. In this case the power is supposed to be generated with blast-furnace gas engines and the cost of power is taken at 0.03 francs, or 0.58 cent, per kw-hour, or, say, $51 the kw-year. In this case the ton of steel comes out as $18.62 for rail steel and $19.78 for



TILTING AN 8-TON ROCHLING-RODENHAUSER FURNACE.

soft boiler-plate steel. These figures include the charge for the molten Thomas steel ($15.54).

It is said that the Rochling-Rodenhauser type of furnace has now been so thoroughly tested in continuous work that there is no doubt about its reliability. The 3- to 5-ton furnace was worked continuously for a whole year, almost all the time producing steel for rails, and more than 5000 tons of rails have been sold from Völklingen to different customers at profitable prices.

For some time past steel made in a Röchling-Rodenhauser electric furnace has been manufactured into rails of standard section No. 8 for use on the Prussian State Railways.

The administration of the Prussian State Railways has drawn up specifications with reference to electric furnace steel rails, particularly as to physical qualities and resistance to wear, as follows:

"Tensile strength for track rails, a minimum of 70 kg per square millimeter, or about 99,000 lb. per square inch.

"For point or switch rails, 75 kg per square millimeter, or about 160,000 lb. per square inch.

"For ordinary basic Bessemer or Thomas rails a tensile strength of 60 kg per square millimeter, or about 85,000 lb. per square inch, is stipulated.

"Elongation, in the case of electric steel rails, a minimum of 10 per cent, determined on samples 200 mm (about 8 in.) between marks.

"Drop tests specify 80 mm minimum bend (about 3 3/16 in.) on a bar 1 m (39.37 in.) between supported ends, with a falling weight of 1500 m-kg (about 10,800 ft.-pounds).

"Guaranteed life of track rails, 10 years; or point rails, seven years."

The chief differences between ordinary Thomas steel rails and electric steel rails are shown in the following table, the figures being mean values:

	C.	P.	S.	Mn.	Si.	Tensile strength, lbs. per sq. inch.	Elongation, per cent.	Contraction, per cent.
Electric steel	0.54	0.056	0.042	0.984	0.21	119,000	15.4	24.1
Thomas steel	0.36	0.073	.....	1.127	....	97,000	17.6	26.2

The composition of the electric steel rails is similar to ordinary Thomas steel rails, the higher carbon content corresponding to the specified higher tensile strength. "The favorable result of the electric steel rails can only be obtained through the 'killing' of the material in the electric furnace under a slag which facilitates deoxidation and escape of gases."

The Pinch Phenomenon in Electric Furnaces.

A paper by Mr. Carl Hering, consulting engineer, of Philadelphia, deals with the working limit in electrical furnaces due to the "pinch phenomenon." The pinch phenomenon itself was described in Mr. Hering's paper in our Vol. V, p. 223.

On the basis of Dr. Northrup's mathematical theory of the pinch effect, Mr. Hering has derived a method of calculating the critical current density which can be used in an electric furnace. The fundamental idea is simply this: The pinch effect produces a pinch pressure which sucks the liquid from the center and forces it out near the ends, thus producing a difference in level which is equivalent to a hydrostatic pressure. A condition of equilibrium is reached when this hydrostatic pressure just balances the pinch pressure.

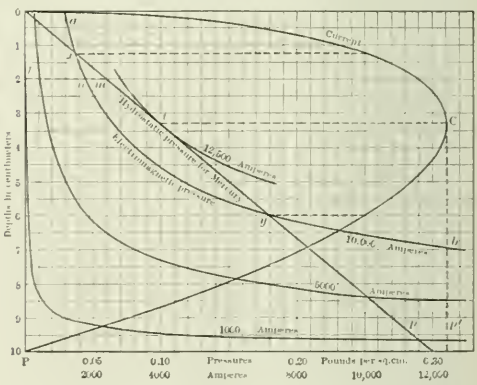


FIG. 1.—PINCH PHENOMENON FOR CIRCULAR CROSS-SECTION.

For a circular cross-section the results are plotted in Fig. 1, where the vertical distances *d* represent the differences in levels in centimeters for an original depth of 10 cm of liquid and the horizontal ones represent pressures in pounds per square centimeter. Let the liquid be mercury.

The hydrostatic pressure increases in direct proportion to the depth and is, therefore, represented by a straight line *Op*, which is quantitatively correct for mercury. The "pinch" pressures are independent of the specific gravity of the liquid, being dependent only on the current and the cross-section. Calculating these for the various differences of levels gives for a current of, say, 10,000 amp, the curve *ab*. This curve merely gives the pressures which that particular current would produce if the column had contracted (from any cause whatsoever) to

those differences of level, or had those respective cross-sections originally.

Equilibrium will be reached when these two opposing pressures balance each other; that is, at the intersections of this curve with the slanting straight line *Op*. It will be seen that there are two such points, *x* and *y*, hence there are two different levels for the same current.

It can be easily seen that for the higher level *x*, which in this particular case means a depression of 1.2 cm, the equilibrium is stable, while for the lower level *y* the equilibrium is unstable. That is, if equilibrium *y* is disturbed the contracted section will become smaller and smaller and rupture will take place.

It will be seen, therefore, that the current may be well within the safe limit, causing only the upper, small and perfectly stable level, yet if some mechanical force then acts to

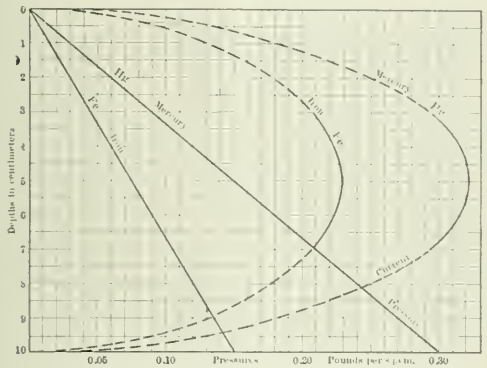


FIG. 2.—PINCH PHENOMENON FOR RECTANGULAR CROSS-SECTION

depress the level to a lower point, the unstable level may be reached in which case the same apparently safe current will be sufficient to cause the rupture. Such a mechanical depression could be produced by some floating infusible material, a loose fragment of firebrick, etc., or by stirring with an insulated rod in a narrow channel. It is, therefore, not always safe to conclude that if the normal current produces only a slight depression, there is no danger of rupture.

By drawing the corresponding curve for 5000 and 1000 amp it will be seen that these two points of intersection move further apart as the current diminishes, which means that a disturbance of the level becomes less dangerous. On the other hand, the curve for the greatest possible current of about 12,500 amp, becomes tangent to the straight line at *t*, which means that the two points have come together.

By calculating the currents required to reduce the levels to the various depths *d*, the curve *OCP* is obtained, the horizontal distances of which are currents instead of pressures. The curve is seen to be re-entrant, returning back to zero. Starting at *O*, where there is no depression, it will be seen that the current must be increased to large values before any marked contraction occurs. After that, however, the level falls quite rapidly with a small increase of current, until the maximum possible current is reached at *C*, after which even a smaller current will again be sufficient to balance the increasing hydrostatic pressure, because the cross-sections are less and the current densities are greater. The lower part of the curve is, however, only of theoretical interest, for at the maximum point *C* the state of unstable equilibrium begins, and in practice rupture, therefore, immediately follows; hence this lower half of the curve in practice becomes a vertical line *CP*.

If a horizontal line is drawn from the upper point of intersection *x* of the pressure curve for 10,000 amp, to the current curve, it will be found to intersect it at 10,000 amp, as it should. The same is true of the lower intersection or of any of the others; and the pressure curve for the maximum current of about 12,500 amp, will be tangent to the straight line at *t*, namely, at the same level as the maximum point, *C*, which important point is termed the *critical point*.

For materials of different densities the hydrostatic pressure is, of course, proportional to the density, but the current is proportional to the square root of the central pressure and therefore to the square root of the density; hence the currents for the critical point will not vary as rapidly as the densities of different materials.

The curves in Fig. 2 give the actual figures for a rectangular channel 10 cm deep and 5 cm wide when the conductor is mercury. The scales and co-ordinates are the same as in Fig. 1. The straight line *Hg* gives the hydrostatic pressures at the various depths. The current curve *Hg* is shown dotted where its shape is not known, and in full where it can be calculated with close approximation by the Northrup formula.

It will be seen that the critical point is reached when the contraction has lowered the level to 5 cm, just half the original depth. The maximum current then is 12,900 amp. Moreover, the contraction increases very rapidly just prior to this current, hence it would begin to be unsafe long before this level has been reached.

If *G* is the density and *H* the original depth of the liquid conductor in centimeters, the critical current density *CD* in amperes per square centimeter is:

$$CD = 221 \sqrt{G/H}.$$

For a small trough 2 in. deep and 1 in. wide the critical current would be about 3300 amp. For 4 x 2, about 9400 amp. For 6 x 3, about 17,000 amp. About 75 per cent of these values would probably be a safe working limit if the channel is quite uniform, if the surface of the molten liquid is reasonably free from floating, heavy, non-conducting materials and if the liquid is not too viscous.

Since the theory is based on ideal "static" conditions, Mr Hering has made a series of actual tests under actual "dynamic conditions," due to the rapid agitation which always accompanies the phenomenon. The tests were made on a small scale with mercury and the results were given in an appendix to the paper. The chief result is that in using the formula in the paper one will be on the safe side in practice.

From the results of these tests it would seem that the width of the channel has no effect on the critical current density, or, in other words, that the critical current increases in direct proportion to the width. The tests were not accurate enough to show whether this was strictly correct.

It would also seem that for a given area of cross-section the critical current would be the same whether the channel were made deep and narrow or wide and shallow.

Changes in the proportion of the height and width seem to have only a small influence on the maximum possible current density; therefore, the best possible shape of a rectangular cross-section probably depends on other considerations, like the loss of heat, which is least when the cross-section is a square. Another factor which may be even more important is that the shallower the channel the greater is the danger due to the contraction caused by obstructions or floating masses. The length of the channel also becomes an important factor, if, with a relatively deep channel, it can be made so short that the material displaced by the pinching effect piles up very high on both sides so that the hydrostatic pressure is rapidly increased; the critical current densities ought then to be very much higher. Confining the material in a covered channel, or using an external magnetic field, ought to enable higher current densities to be reached.

Mr. Hering's paper was discussed by Dr. Northrup, who thought that the theoretical formulas in the paper would probably prove more reliable in their application to large furnaces than deductions from the small-scale experiments.

Mr FitzGerald mentioned that the largest scale on which

observed the pinch phenomenon was when they tried to melt aluminum in a 60-kw induction furnace, the depth of the channel being 6 in. or 7 in., the width 2 in. Success of melting was prevented in this case by the pinch phenomenon.

The Lash Process and the Electric Furnace.

Mr. A. J. FitzGerald, of the FitzGerald & Bennie Co. Laboratory, of Niagara Falls, N. Y., explained in an interesting paper in which way the Lash process, often before noticed in this journal, can be applied to the electric furnace.

The Lash process is based on the observation of Mr. Horace W. Lash that when an intimate mixture of iron ore, carbon, fluxes and cast-iron borings is heated, reduction takes place and by a suitable proportioning of the mixture the desired grade of steel can be obtained. Instead of cast-iron borings granulated or shotted pig iron may be used (which can be readily made with the aid of steam and is said to be supplied by pig-iron makers at the same price as ordinary pig iron). The important constituents of the mixture are, therefore, pig iron, ore and coke.

Hundreds of tons of steel have been made in the open-hearth furnace using the Lash process and it has been shown by experience that a superior quality of steel is obtained in this way and that the cost of producing the steel is in general lower than when the regular methods are employed.

In comparison with the open-hearth, the electric furnace has certain advantages for carrying out the Lash process. In the electric furnace the atmosphere is neutral, while in the open-hearth furnace it is oxidizing, thus making more difficult the proper control of the carbon content of the steel produced when the charge is melted down. In working with the open-hearth furnace it is necessary to use a certain amount of pig iron or scrap, or both, in addition to the Lash mixture, while in the electric furnace this should not be necessary, and since the cost of a unit of iron in the mixture is much less than in the form of pig iron or scrap, an economy would be introduced which would offset, at least to a certain extent, the high cost of generating heat electrically.

The experiments made by the FitzGerald & Bennie Laboratory with the Lash process in an electric furnace of the Héroult type were described in detail in our Vol. VI, p. 493. The energy expenditure was approximately 1.63 kw-hours per kilogram or 0.25 hp-year per metric ton.

Mr. FitzGerald then gave various tables of the composition of the Lash mixture when used in the open-hearth and in the electric furnace, and in comparison with the ordinary open-hearth process. These tables are summed up in the following table giving a comparison of different methods of producing 100 tons of steel ingots

Raw materials.	Open hearth furnace, scrap and pig.	Open-hearth furnace, pig and ore.	Open-hearth furnace, Lash process.	Electric furnace, Lash process.
Pig iron	50 tons	94 tons	60.1 tons	40.7 tons
Scrap	57 tons	"	"	"
Ore	2 tons	26 tons	75.2 tons	103 tons
Coke	"	"	13.4 tons	19.5 tons

So far as the open-hearth furnace is concerned nothing more can be expected in the application of the Lash process than is shown above. It may be that some further reduction in the amount of pig iron used may be reached.

The experiments with the electric furnace, however, have not been carried so far, and it is, therefore, probable that better results can be obtained than those indicated above. It may be possible, for example, to reduce the percentage of granulated pig iron used in the mixture. This possibility suggests the interesting question: Why use pig iron at all? Is it not possible in the electric furnace to use a charge consisting only of ore, carbon and fluxes?

The excellent and well-known work of Stassano has answered the latter question affirmatively, and he has shown that charging his furnace with a mixture of ore, carbon and fluxes, paying careful attention to the proportions, it was possible to produce steel of the desired grade. Seeking an answer to the first question, it must be remembered that Lash's experiments showed that when various mixtures containing different percentages of cast-iron borings were used it was found that the mixture which contained very little or no metallic iron failed to react in a satisfactory manner, and it was this result which in great part led to the development of the process in its present form.

If mercury and iodine are rubbed together in a mortar there is no appreciable reaction, but if the mixture is moistened with a little alcohol the mercury and iodine combine to form iodide. The analogy is very far from being exact, nevertheless it may be used in considering the Lash experiments. Apparently the presence of pig iron intimately associated with the mixture of ore and carbon assists in a marked way the reaction between these constituents of the charge.

Experiments have been made in the electric furnace by Mr. Robert Turnbull for the purpose of comparing the reaction of the Lash mixture and a charge containing no granulated pig iron. The results obtained confirmed the belief in the importance of the pig-iron constituent, for not only was the power consumption excessive where no metallic iron was used, but the mixture boiled or frothed in a very troublesome manner instead of melting down in a relatively quiet way, which is characteristic of the Lash process. Moreover, where no pig iron was used the consumption of electrodes, in a furnace where the heating is done by drawing arcs between the electrodes and the charge, is very much greater than when the Lash process is employed.

Therefore, in answer to the question as to why pig iron should be used at all, it may be replied that its presence reduces the amount of energy required to produce a unit weight of metal from the ore, and that, by making the reaction proceed more quietly and rapidly, it diminishes other expenses connected with the working of the electric steel furnace.

Large Electric Iron and Steel Furnaces.

A paper by Mr. Remo Catani, of the Société Elba, of Elba, Italy, emphasized that if the electric furnace is to compete with other processes for iron and steel production it must be of large capacity.

In a paper read before the Associazione Elettrotecnica Italiana (see our April issue, page 153), the author has shown that blast-furnace pig iron and electric pig iron have the same cost price when

$$y = x\left(0.115 + \frac{4}{n}\right)$$

where

x is the cost of a hp-year, in lire.

y is the cost of a ton of coke, in lire.

n is the number of kilograms of pig iron produced per hp-day ($n = 8$ represents at present quite good electric furnace practice. Dr. Héroult hopes to get $n = 12$, since he expects 120 tons of pig iron per day from a 10,000-hp plant).

In the above formula it is assumed that the gases of both blast and electric furnaces are entirely utilized in gas engines, and a year is composed of 8000 hours.

For a given value of x or y the value n varies hyperbolically with y or x. This fact proves the importance of furnace efficiency in the economic study of electric pig iron.

The author has further found that if only blast-furnace gas is utilized, the preceding formula is to be changed as follows:

$$y = x\left(0.185 + \frac{4}{n}\right)$$

for which we have, for $n = 12$ (Héroult's figure) very approximately $x = 2y$. This means that electric pig iron should cost as much as blast-furnace pig iron when the price of a hp-year is twice the price of a ton of coke, and the electrothermic reduction of iron ores should be cheaper than that in a blast furnace when a hp-year costs less than two tons of coke.

The author then discusses the importance of increasing the

power factor so as to have it as nearly equal to unity as possible. This may be accomplished either by lowering the frequency or the coefficient of self-induction. To lower the coefficient of self-induction is a more interesting problem than to lower the frequency, because very often it is a question of making a larger electric furnace using a given current, but even when the installation is being designed it is not convenient for the electrical machinery to use a very low frequency. The author considers 25 cycles as the best frequency for electrometallurgical purposes.

In the last part of his paper Mr. Catani discusses single-phase versus polyphase current operation for large electric furnaces. With reference to a certain 7000-hp, three-phase furnace, built in Sweden, for carbide manufacture, the author claims that if it was changed to single-phase operation it would have a capacity of 12,000 hp instead of 7000 hp without any change in its dimensions.

A three-phase furnace versus a single-phase furnace of the same power presents some peculiar features, of which some are considered as advantages and others as inconveniences.

The advantages of three-phase are: Neutrality of the hearth; greater facility of making the furnace rotary, above all if electrodes remain in their lines during the rotation; cheaper electrical machinery (alternators, line, transformers, etc.). As inconveniences of three-phase may be considered the following features: Larger cross-section of electrodes put in furnace; greater number of electrode holders or larger electrode holders in an unfavorable position, being exposed to the radiation of the furnace; necessity of running to full load or overload in order to have a good efficiency; possibility of short-circuits through the walls of the furnace without passage of the current through the bath; larger dimensions of the furnace.

In studying the means of reducing the coefficient of self-induction it is to be remembered that it depends upon the permeability and that it is necessary to avoid in the furnace construction any material of high permeability, at least in the loop formed by the conductors of the current.

"From these considerations is derived the possibility of making very powerful electric furnaces, much more powerful than those built up to now, corresponding to the very large electrical powers actually reached in steam or water turbines, alternators, transformers, etc., and we hope that if such powerful electric furnaces will be built, electric furnaces will produce iron and steel at as low a price as the best common metallurgical furnaces."

The Present Value of Electric Structural Steel.

Mr. HENRY D. HIBBARD, consulting engineer with the Taylor Iron & Steel Company, thinks that possibly the electric smelting of steel, now entering the commercial stage, is in danger of having its progress retarded by the zeal of its friends, who may claim more for it in some respects than the future will justify.

The object of his paper is chiefly to compare from a cold business standpoint the value of electric steel with that of steel made by the Bessemer and open-hearth processes. Comparison with crucible steel is less needed because the differences are less.

The advantage which electric steel melting offers may in a general way be said to consist in the ability to melt or to retain melted a large quantity of steel in an environment either non-oxidizing or with access of oxygen to the metal under control, and also with controllable temperature in the metal, both as to degree and duration. The beneficial result of these advantages lies more in the direction of improved quality of the product than in lessening its cost.

The specific features of electric furnace operations which tend to improve the product are the elimination of oxidation products, of phosphorus and sulphur, and, as a result therefrom, an improvement of its quality and a possibility of having less manganese in the finished metal.

Oxidation Products.—These are the most uncertain of all the poisons to steel, because they are not determined and are dealt with by indirect methods. They may be itemized as being chiefly oxides of iron, manganese, silicon and carbon, and silicates of the two metals mentioned. The usual analysis does not reveal the presence or amount of these oxidation products.

With respect to these oxidation products which seem unavoidable in the oxidizing atmosphere of the converter and open-hearth, the reducing atmosphere of the electric furnace is of chief importance.

The electric furnace in dealing with the oxidation products in crude steel enables the fusion to be continued at will until they are removed as completely as desired through agglomeration and gravitation, or by their reduction to elements through the action of some reducing element at the high temperature maintained.

Another matter comes in here, however, for consideration. If steel containing less than the usual amount of the oxidation products be found to have for that reason increased commercial value, something can be done when using the Bessemer and open-hearth processes to attain some of that value, especially with the latter by proper treatment of the slag and bath, and by allowing enough time. "If the electric steel furnace induces consumers to pay for high quality, it will, indeed, have justified its existence. Until then its value, because of its ability to eliminate oxidation products, must be held as not determined."

Phosphorus.—The basic open hearth can now produce regularly from the very ordinary materials steel so free from phosphorus that very little is left for the electric furnace to do even if it were possible by its use to remove every atom. "The value of the ability of the electric furnace to make structural steel exceedingly low in phosphorus cannot be great from a commercial point of view."

Sulphur.—The effect of sulphur on the physical properties of the finished steel is so slight that satisfactory reasons do not appear for closely limiting and specifying its permissible content. As in the case of the oxidation products, the trouble from sulphur is more in evidence during manufacture than in the finished steel. "The power of the electric furnace to eliminate sulphur from steel, while undeniable, must be held, nevertheless, as of little real value until the minimum attainable in the open-hearth process is shown to have an important detrimental effect on the product." * * * "It must be undubitably shown that the properties of the finished steel are better than those given by other methods at about the same or lower cost before the electric furnace can take its place as one of the standard commercial means for producing or finishing structural steel."

"It is stated that the German Government is paying $4 a ton more for rails rolled from electric steel than for ordinary rails. Such action might be for either of two reasons: First, that the electric steel rails have been demonstrated to be worth that additional price, or, second, that the $4 amounts in part at least to a Government subsidy aimed to put forward the development of the electric furnace. As the final test of a rail consists in wearing it out by actual service, which can hardly have been done yet, it would seem fair to assume at this time that the $4 includes a subsidy. The total amount of such subsidy cannot be very large up to date."

Discussion.

With respect to Kjellin's paper the question was asked as to the material from which the pole-pieces or pole-plates (through which the current is introduced into the working hearth) are made. Mr. Hay replied that they are made from cast steel, but are not in direct contact with the fused bath. They are protected by a lining made from magnesite and tar; under the action of the heat the tar disappears. The magnesite conducts when heated. The rest of the lining in the furnace is dolomite.

With respect to the Lash process Mr. FitzGerald explained that if sufficient quantities of cast-iron borings should not be

available, granulated pig iron could easily be used. There is no difficulty in making it. A convenient method is to pour the metal, while a jet of steam is directed on it at a right angle.

Mr. Lane emphasized that there was a sufficient supply of borings and turnings, and the process seemed to solve the problem what to do with them, especially for manufacturers of small castings.

Dr. R. Moldenke concurred with thim in this view; he considered that for manufacturers of small castings the electric furnace as an auxiliary might be valuable, by buying steel ingots, heating them almost to the melting point in a regenerative furnace finishing in an electric furnace and then casting. Such a process would be economical.

With respect to the doubt expressed by Mr. Hibbard whether electric steel refining would be really commercially worth the cost, Dr. Richards replied the best answer was the existence of some 80 electric furnaces in regular commercial operation.

Mr. Anthony Victorin gave a graphical representation of what the electric furnace can do under the conditions existing in a steel casting plant in Philadelphia. He compared the open-hearth process, the Tropenas converter, these two processes combined with the electric furnace, and finally the all-electric process, plotting graphically the possible commercial profits. His results appeared quite favorable to the electric process.

This closed the symposium of papers on the electrometallurgy of iron and steel. As specially interesting to steel men the following paper on pyrometry was then taken up:

A New Radiation Pyrometer.

A recent modification of the Féry radiation pyrometer was described in a paper of Mr. Charles E. Foster, of the Taylor Instrument Companies, of Rochester, N. Y.

While in so-called optical pyrometers, the radiation corresponding to a certain wavelength serves as indication of the temperature on the basis of Wien's law, the basis of the temperature measurement in the radiation pyrometer is the total radiation acording to the Stefan-Boltzmann law.

In the original Féry radiation pyrometer the radiation is concentrated on the junction of a small thermo-couple. The electromotive force set up in the couple by the heat is indicated by a galvanometer, which is connected by leads with the pyrometer, and which has carefully to be levelled. In the new type, which is also due to Professor Féry, a small strip made up of two metals having very different coefficients of expansion, and coiled to the shape of a spiral, replaces the thermo-couple. The spiral unrolls when heated, and a pointer marks this movement on the scale. The temperature of the air must be taken into account by adjustment of the zero of the instrument. The great advantage of the new type over the older one is that it is an absolutely self-contained instrument.

As far as tests go the instrument keeps up its calibration very well. At 1000 deg. C. the accuracy is well within 2 per cent.

The paper was discussed by various speakers, who related chiefly their experience with optical and radiation pyrometers.

Furnace Electrode Losses.

Mr. C. A. Hansen, of the research laboratory of the General Electric Company, presented a very interesting paper, giving in a long series of diagrams the results of an extended investigation of the losses due to the electrodes in an electric furnace. There are two kinds of losses: Joulean heat developed by the electric current in the electrodes, and heat transferred by conduction from the hot inside of the furnace to the cold outside.

That the conditions are quite complicated became evident in the early experiments of the author, when he found in a special case the striking result that by increasing the effective resistance length of the electrode and increasing the current density so that the Joulean heat losses were more than doubled, the total electrode loss was not increased. Assuredly, then, in this case the efficiency was increased by increasing the length of the electrode embedded in the wall.

Later, in another experiment, an even more surprising result was encountered when it was found in one case that the cooling water from the outside electrode water-jacket carried off less heat than corresponded to the Joulean heat developed in the electrode itself by the current. The inference is, of course, that "the electrode is at least as hot as the furnace interior by reason of the C^2R heating and not alone blocking the flow of heat from the furnace outward, it actually feeds heat in both directions, the main portion naturally going to the cooling water-jacket."

A large part of the paper is devoted to a comparison between amorphous carbon and artificial-graphite electrodes. The chief conclusions of the author are as follows:

For electrodes in the furnaces with which he experimented carbon electrodes are less wasteful of heat than graphite electrodes of the same cross-section at current densities below 200 amp per square inch. Varying the length of electrode may, to some extent, vary this critical current density.

In furnaces taking 500 kw, the electrode losses can easily reach 15 per cent of the total load impressed. Since the electrode losses are to a certain extent independent of the length of the furnace, if we shorten the furnace we increase the electrode loss to any amount above 15 per cent.

It also seems more reasonable to assign a ratio of the heat conductivities of graphite and carbon of about 8 to 1 under the conditions described. The ratio is brought down to this value from 18 to 1 (cold) probably owing to the partial graphitization of the carbon, and the ratio may also vary somewhat with length.

Mr. Hansen also gave many interesting diagrams, showing the variations of various physical properties of carbon and graphite with temperature.

The paper brought out a very extended discussion in which Messrs. Lidbury, Hering, Richards, Northrup, Hansen and others participated. Mr. Hering pointed out that if one makes one point or portion of the electrode hotter than the inside of the furnace, this will act like a "heat valve," heat flowing off from this point toward the inside of the furnace.

Electrochemistry and the Conservation of Natural Resources.

In the evening or Thursday Dr. E. G. Acheson delivered his presidential address on the function which electrochemists will have to fulfill in the movement toward the conservation of our national resources.

The opening thought of Dr. Acheson's address carried him back in memory to the joint conservation conference held in Washington, D. C., in December of last year. He told how he felt a thrill of pride in being one of the people of the United States when President Roosevelt stated this nation was first to take steps to conserve natural resources. It was with profound pleasure that he realized that the people of the United States are now great enough to call a halt in the heedless consumption of the world's stock of necessities; rich enough to construct great works for the attainment of that end; scientific enough to create artificial duplications of the natural and add to the list of the materials nature has provided for man's use, and, lastly, humane enough to devote some thought, work and resources toward providing for posterity.

Dr. Acheson reviewed briefly the work of the conference, pointing out the disposition to create expensive waterways, but the failure of the body to take steps looking to the actual conservation of our perishing resources caused regret and surprise. It was his expressed belief that to fully utilize the natural inexhaustible resources, while conserving the natural exhaustible resources, would be an example for the entire civilized world to follow, and a step well calculated to sustain the progessive spirit of Americans. He felt it was possible for Americans to

build as no other people have built, and he pointed out how this might be done through the aid of electrochemistry.

It was evident that the retiring president of the American Electrochemical Society had most carefully studied the "great open door" before that organization, and in more than one way he told how wonderful things might be accomplished.

An illustration was made in connection with the sodium nitrate field. The center of this new industry is now in Norway, but the speaker's words intimated that he wondered how long Americans would submit to this condition. Dr. Acheson emphasized that at the present rate of importation the next 20 years would call for the sending of no less than $473,650,495 out of the country, a sum, he coolly stated, quite enough to dig the Panama Canal and leave a good balance to the country's credit.

Dr. Acheson then outlined the logical course to pursue in the conservation of natural resources. His plan involves forest creation and protection, the impounding of waters, the construction of power plants, and lastly the development of waterways, ushering in the electrochemical age. With this Dr. Acheson associated a new synthetic chemistry, providing wonderful possibilities. Electrochemists are even now earnestly at work on

PRESIDENT E. G. ACHESON.

problems of great magnitude, citing the electrometallurgy of iron and steel.

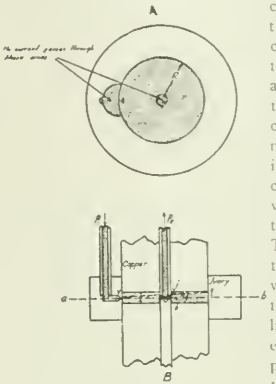
Leaving the question of conservation, Dr. Acheson turned again to electrochemistry, saying the field is much too extensive and rich to be monopolized by any one or two of the professions. He portrayed a brilliant future, and in conclusion he said: "The government will, I think, ere long recognize the electrochemists, and our society in particular, as an important factor in the industrial and commercial life of the nation, and as a means of materially conserving the interests of posterity. It may be that it will in time see the advisability of establishing a department devoted to these interests."

Friday Session.

Ammeter For Large Alternating Currents.

A paper by Dr. E. F. NORTHRUP, of the Leeds & Northrup Company, of Philadelphia, describes a new type of ammeter for the accurate measurement of alternating currents over 1000 amp. The instrument is based on the "pinch effect" or (what is at the bottom of this effect) the centripetal pressure which exists in the interior of a liquid conductor carrying an electric current.

The field of special usefulness of this new instrument is to be found in the accurate measurement of alternating currents of over 1000 amp. there being no assignable upper limit to the current which may be measured. It is especially suitable for determining exactly the transformation ratio of heavy-current series transformers. The fundamental principle is indicated in the adjoining illustration, where *B* is a vertical section and *A* a cross-section on the line *ab* of *B*. *Hg* is a cell filled with mercury. When an electric current passes from *j* to *k* through the mercury, a difference of hydrostatic pressure is created between the outer and inner circumferences of the circular cell. In order to determine this pressure-difference a communication must be established between the inner and outer circumferences of the cell. This may be accomplished by the arrangement diagramatically shown in the section *B*. When the current flows, the mercury will tend to flow down the tube p_1 and up the tube p_2. This flow will continue until the difference in level at which the mercury stands in the tubes p_1 and p_2 establishes a pressure-difference equal and opposite to that produced by the curent between the inner and outer circumferences of the cell. By measuring the difference in level between the tubes p_2 and p_1 the pressure-difference produced by the current and, therefore, the current itself may be determined.



PRINCIPLE OF AMMETER

In order to magnify the difference in the level of the mercury a column of colored water is used as indicator. The mercury well, which communicates with the center of the cell, is given a large diameter and the surface of the mercury in this well only rises a fraction of a millimeter when the water column rises 50 cm or more. With this construction the friction which the surface line of the mercury makes with the wall of the well is vanishingly small and has no influence on the precision of the indications or on the accurate return to zero of the water column when the current is turned off.

The theory of the instrument is given in detail, and an account is given of the many difficulties which had to be overcome in the mechanical construction, but which have now been overcome successfully. The instrument can be made so exact that it may be used for an absolute measurement of current. The arrangement of the instrument for this purpose is described.

Electroplating.

A paper by Dr. EDWARD F. KERN, of the School of Mines, Columbia University, pointed out the importance of smooth, solid, coherent deposits for electroplating as well as refining, and discussed in detail one of the means to this end, namely, the addition of certain reagents (gelatine, tannin, etc.), which, when present in very small quantities, often improve the quality of the deposit in a very effective manner. Such materials the author calls "addition agents."

Dr. Kern first gives a review on the literature of the subject and then an account of an extensive experimental investigation made by him in conjunction with measures of Janis, Fabran and Frapwell.

For depositing copper, lead and silver the following electrolytes were employed: cupric sulphate, cuprous chloride and cupric fluo-silicate; lead nitrate and lead fluo-silicate; silver nitrate and silver fluo-silicate. The addition agents tried with these electrolytes were gelatine, resorcinol, pyrogallol and tannin.

For deposition of nickel the following electrolytes were employed: nickel fluo-silicate, nickel chloride, nickel sulphate and nickel fluo-borate because of their higher solubility and their cheapness of preparation.

For the deposition of iron, experiments were made with fer-

rous sulphate and ferrous chloride solutions. The results of this experimental investigation are as follows:

The deposits of lead, copper and silver tend to form more crystalline and less coherent with higher current densities. The smoother deposits form with lower current densities.

With rise in temperature of the electrolytes of lead, copper and silver up to 60° C., the tendency of the depositions is to form more coherent, denser and less crystalline.

The fluo-silicate electrolytes of lead, copper and silver give more coherent deposits than those formed in the nitrate electrolytes of lead or silver, or in the sulphate or chloride electrolytes of copper.

The crystallization of the deposits of **lead**, formed in an almost neutral electrolyte of lead nitrate, is restrained by having present one part of either tannin, resorcinol, pyrogallol or gelatine per 250 parts of electrolyte. The deposits, however, in all cases were composed of a mass of non-coherent crystals. Tannin is the most satisfactory "addition agent" for lead nitrate electrolyte.

Gelatine, tannin and pyrogallol when present in lead fluo-silicate electrolyte in the proportion of one part by weight to 5000 parts of electrolyte causes the lead to deposit as a smooth, dense, coherent mass. The most effective of these "addition agents" is gelatine, the next is tannin, and the least effective is pyrogallol. Resorcinol is not a suitable "addition agent" for this electrolyte.

The deposits of **copper**, from copper sulphate electrolytes, are rendered smoother and brighter by the presence in the electrolyte of either tannin, resorcinol or gelatine; tannin is the most effective, resorcinol is less, and gelatine is the least effective of the three. Pyrogallol is not a suitable "addition agent" for this electrolyte, as it causes the deposited copper to form dark colored.

The deposits of copper from copper fluo-silicate electrolyte were rendered smoother and brighter by the presence in the electrolyte of either tannin, pyrogallol or gelatine. Tannin is the most effective of the three.

The deposits of copper from cuprous chloride electrolytes are not improved by the presence in the electrolyte of either gelatine, pyrogallol or dextrine. Elevation in temperature of this electrolyte does not cause the copper to deposit more coherent.

EFFECT OF ORGANIC ADDITION AGENTS IN THE ELECTROLYTES OF LEAD, COPPER AND SILVER.

Electrolyte.	Gelatine.	Tannin.	Pyrogallol.	Resorcinol
$PbSiF_6$	Densest depot	Denser deposit	Dense deposit	Deposit not improved
$CuSiF_6$	More smooth and bright deposit	Most smooth and bright deposit	Smooth, dense deposit	Deposit not improved
Ag_2SiF_6	Coherent deposit	Deposit not improved	Deposit not improved	Deposit not improved
$Pb(NO_3)_2$	Less crystalline and more coherent deposit	Deposit much improved	Deposit not improved	Deposit not improved
$AgNO_3$	More coherent deposit	Deposit not improved	Deposit not improved	Deposit not improved
$CuSO_4$	Brighter and smoother deposit	Brighter and smoother deposit	Dark deposit	Deposit not improved
Cu_2Cl_2xNaCl	Deposit not improved	Deposit not improved	Deposit not improved	Deposit not improved

Silver is deposited as finer crystals and in a more coherent form of electrolytes of silver nitrate and silver fluo-silicate, when the electrolytes are at a temperature of 40° than when at a temperature of either 20° C. or 60° C.

Deposits of silver from silver fluo-silicate electrolyte are more coherent than deposits formed in silver nitrate electrolyte.

Gelatine, when present in silver nitrate, and in silver fluo-silicate electrolytes, in the proportion of one part per 10,000 to 14,000 parts electrolyte, causes the deposit to form as shorter and as smaller crystals, which are more coherent than when gelatine is not present.

Pyrogallol, tannin and resorcinol are not suitable "addition agents" for silver nitrate or fluo-silicate electrolytes.

The presence of free acid in **nickel** chloride, nickel sulphate and nickel fluo-silicate electrolytes causes very low cathode efficiency, whereas the anode efficiency was in most cases over 95 per cent. By continued electrolysis the free acid was neutralized and the cathode efficiency increased. The electrolysis of neutral nickel chloride and nickel fluo-silicate solutions with current densities of 10 and 20 amp per square foot gave very satisfactory deposits and high current efficiencies. Neutral nickel-sulphate solutions were unsatisfactory, as precipitates of insoluble basic salts formed and intermixed with the deposited nickel.

Heating the nickel chloride and the nickel fluo-silicate electrolytes decreased the e.m.f., increased the efficiencies and improved the deposition. The most satisfactory temperature was about 40° C.

During electrolysis of nickel fluo-silicate solutions a small amount of gelatinous silica separated and collected on the bottom of the cells. Heating of these solutions above 75° C. also caused the separation of silica, but very slowly.

A small amount of basic salts separated from the neutral nickel chloride electrolytes during electrolysis, but did not interfere with the deposition. The presence of a small amount of free acid prevented their formation.

The presence of sodium salts in the nickel chloride electrolytes was not very beneficial, whereas its presence in the neutral sulphate electrolytes reduced the e.m.f. over 60 per cent, caused the formation of good deposits and also increased the current efficiency to approximate 100 per cent, when the temperature of the electrolyte was about 60° C. At room temperature the presence of sodium salt in the sulphate electrolyte was of no great benefit.

Satisfactory deposits of nickel were obtained from neutral solutions of nickel fluo-borate electrolytes when the electrolysis was conducted at room temperature and using a current density of 10 amp to 15 amp per square foot. At temperatures above 35° C. the solution was decomposed, causing the precipitation of an insoluble basic salt.

Good deposits of **iron** were contained by the electrolysis of neutral electrolytes containing either 8 per cent of iron as $FeSO_4$, or 6 per cent Fe and 3 per cent Na as sulphates, or 8 per cent Fe and 4 to 7 per cent Na as chlorides. The presence of the larger amount of sodium chloride in the electrolytes prevented the vertical ridging of the deposit and caused it to form smoother. The finer-grained deposits of iron from the sulphate electrolytes were formed in the solutions which contained the sodium salt.

The deposits of iron formed in neutral chloride electrolytes containing sodium chloride were finer grained and more flexible than those formed in the neutral sulphate electrolytes.

The deposits of iron formed smoother when the electrolysis was conducted at 40° C. to 60° C. than when conducted at normal temperature.

The effect which the presence of organic addition agents has upon the deposits of lead and silver from their fluo-silicate and their nitrate electrolytes and upon the deposits of copper from its fluo-silicate and its sulphate electrolysis cannot be attributed to any specific physical property of the addition agent. The only property in common of the organic addition agents which were found to be beneficial in improving the deposits of lead, copper and silver is the larger number and the similar arrangement of the hydroxyl radicals.

At the present time, with the lack of reliable data, the only means of selecting the most suitable addition agent is patient experimenting. However, this general statement may be made: That the greater the molecular weight of the addition agent and the larger the number of adjoiningly grouped hydroxyl (and amine) radicals which the compound contains, the more effective it is in producing denser, brighter, less crystalline and more coherent deposits of lead, copper and silver.

A theory which may be deducted from the above generalization is that the function of an addition agent, in an electrolyte, is to maintain a reducing menstruum around the cathode, which in turn causes the electro-deposit to form denser and smoother.

The author cites various facts and observations in support of this hypothesis.

Deposition of Aluminium from Aqueous Solutions.

A paper by Prof. S. A. TUCKER and E. G. THOMSSEN, of Columbia University, described a method of depositing aluminium from an aqueous solution, which, while not of commercial value, is of considerable scientific interest.

From experiments carried on with copper and other metals deposited on a rotating cathode, it is known that the current density can be raised very greatly and the nature of the deposit be generally improved. It seemed possible that if the speed of rotation could be sufficiently increased the current density might be raised to such a high value that metals could be deposited from aqueous solutions which under ordinary circumstances would not deposit at all.

In the experiments cathode speeds up to 20,000 r.p.m. were used and minute deposits were obtained with higher speeds from a concentrated or pasty electrolyte. By chemical analysis these deposits were proved to be aluminium. On exposure to the air, however, the deposit blackened. Temperatures from 30 to 40° C. gave the best results. When using the highest speeds it was possible to burnish some of the deposits which were slightly black on a buffing lathe with rouge, the deposit then having the same appearance as polished aluminium.

In the later experiments, which gave the best results, an anode of aluminium, a cathode of brass and an electrolyte of a pasty solution of aluminium chloride at a temperature of 30 to 40° C. were used with a cathode speed of 15,000 r.p.m. and an anodic current density of 0.085 amp per square centimeter.

In the discussion which followed Professor Tucker said that he has succeeded in depositing calcium, magnesium, etc., from aqueous solutions in the same way by the use of a rotating cathode. In the case of calcium Dr. Watts questioned whether the deposits consisted of metallic calcium, as it might have been a subchloride of calcium. As to aluminium Professor Tucker stated that the identity of the chemical deposit as metallic aluminium had been established by analysis.

Mr. A. H. Cowles referred to the alleged plating of the top of the tower of the Philadelphia Public Building with aluminium. True, the electrolyte was rich in aluminium, but also in tin; and it seems certain that the deposit produced actually consisted essentially of tin.

Mr. William Koehler said he had succeeded in depositing aluminium from a dilute chloride solution upon an iron cathode. While the process is not now a commercial proposition, it is possible.

Electrolytic Deposition of Lead and Zinc.

A paper by Prof. S. A. TUCKER and E. G. THOMSSEN, of Columbia University, refers to a patent of Classen, according to which deposits of zinc can be much improved by the addition of licorice root or extract or other similar organic compounds to the electrolyte. The present authors have studied the effect of such additions on the deposition of lead and zinc.

They found that in the case of both lead and zinc the deposit actually obtained exceeded that of theory in nearly every instance. Of the two substances used, the licorice root gave higher results than the extract. The extract of licorice also gave better deposits than those obtained with the root. By a special investigation it was found that this excess of weight was due to organic matter (licorice) being carried over with the metal deposited.

The deposits in every case were exceedingly good, adhering firmly if the cathode was perfectly clean at the start and if the current density was not too high. The lead comes out unpolished, but with zinc, if the cathode is first polished, a bright coat of zinc is obtained.

When heated, the lead adheres until it fuses, while the zinc becomes brittle and peels off readily.

It is impossible to raise the current density to any great extent without impairing the deposit. With 2 amp per square decimeter the deposits become dark, rough and non-adherent. The best results were obtained with a current density of about 0.5 amp per square decimeter.

In order to secure a good, thick deposit of the metals it is advisable to add the organic matter gradually and to keep it well stirred.

In the deposit of zinc it was found that zinc sulphate alone, with the addition of licorice, gave quite as good results as when the electrolyte was made up with the additions as recommended by Classen.

Acetone Solutions for Metal Deposition.

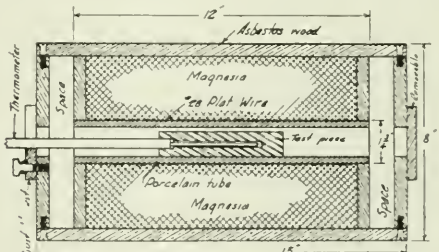
A paper by Dr. H. E. PATTEN and Mr. W. R. MOTT dealt with the electrodeposition of some metals from acetone solutions. They succeeded in depositing sodium and strontium metals from saturated solutions of the iodides in acetone at room temperature, using rather high-current density. Cadmium, tin, antimony, bismuth and arsenic were deposited from solutions of their chlorides in acetone at moderately low density.

Iron and copper were deposited from solutions of their chlorides (-ic) in acetone rather high current densities.

In most cases anode and cathode polarization values were obtained.

Autographic Registration of Cooling Curves.

A paper by Dr. E. F. NORTHRUP, of Leeds & Northrup Company, of Philadelphia, first discusses the advantages of autographic recording apparatus (as distinguished from photographic recorders) and describes a new autographic recorder which will automatically and accurately register energy variations where the available energy is exceedingly small. If the variations in the energy are not too rapid, autographic recording



ELECTRIC FURNACE FOR DETERMINATION OF COOLING CURVES.

can be made to compete in all cases with photographic recording in regard to sensibility and precision.

The complete recorder consists of four essential parts: a differential galvanometer, with a plunger magnet attached to it, for operating periodically a contactor: an eight-day clock, which drives and operates the contacting plunger magnet; a simple mechanism consisting of a screw and two electro-magnets of the plunger type for traveling the pen and the balancing contact; and a paper drive, moved by the clock, which feeds a continuous band of paper off a roll and over an apron carrying it under an ordinary stylographic pen. All parts of the recorder are made up of separate, interchangeable units, which may be easily assembled, disassembled or replaced. The uninterrupted operation of the apparatus is absolutely assured.

Dr. Northrup then briefly discusses various forms of cooling curves and concludes that with a highly sensitive and accurate recorder, the temperature range of which can be modified at will, the form of cooling curve in which the temperature is plotted against time, will yield all the information desired and in a manner most simple and direct. He then discusses the use of electric resistance thermometers versus thermocouples for the

recording of cooling curves and gives various reasons why the resistance thermometer is preferable.

In the concluding part of the paper some practical suggestions are made on the recording of cooling curves of steel. The recorder described in the paper follows the cooling of a sample ½ in. in diameter when cooled in an oven well insulated from loss of heat by a jacket of magnesia. If it is required to take the cooling curves of sheet steel, this may be done by cutting a strip 5 in. wide off the sheet. This strip may be rolled upon a ½-in. mandrel to form a hollow cylinder and used in the oven in the same manner as a solid cylinder with a hole bored in it.

It is important for ease of working to have a properly constructed oven. On page 273 is given the design of an oven which is the outcome of considerable experience and many trials. The casing of the oven is made of a compound of pressed asbestos, known to the trade as "asbestos wood."

The platinum heating coil is wound on the outside of a glazed porcelain tube, the winding being distributed to give uniform temperature throughout the interior of the tube. The glazing is softened by high heat around the wire and retains it in place. The space around the porcelain tube is filled in loosely with powdered magnesia. The quantity of this magnesia may be varied to modify the velocity of cooling and may be removed with ease to inspect the winding or make repairs. A switch, binding post and fuse are mounted upon the outside of the case. The winding is of No. 28 platinum wire and has 11 ohms resistance at room temperature. Extra removable pieces of asbestos-wood permit the end opening to be closed tightly and yet allow the easy insertion and removal of the samples. When at full heat the oven operates directly in 110 volts.

With the outfit of recorder, thermometer and oven described in Dr. Northrup's paper, many samples may be tested in a single day, and the results obtained will be without ambiguity. Differences in the positions of the recalescent points of steel of 1 deg. C are easily located with certainty. The curves which are drawn are drawn on thin semi-transparent cross-section paper and may be easily blueprinted for duplication. Tabulated cooling-curve records of this precision, accompanied with chemical analysis of the samples, ought to yield information of much value in the metallurgy of steel and its protean alloys.

Electrolytic Deposition of Platinum.

A paper by Dr. W. J. McCaughey, of the Bureau of Soils, Department of Agriculture, describes a method of depositing platinum by electrolysis. The primary object was to secure a set of platinum-plated bottles in which to carry on solution studies. Gold is first deposited; although soft, it adheres firmly and offers an excellent surface upon which to build a harder deposit of platinum.

The electrolyte was formed by addition of citric acid to a saturated solution of potassium chlorplatinate. In general it was found expedient to use a solution of the following concentration: 2 grs. potassium chlorplatinate, 10 grs. citric acid, 100 c.c water. This high proportion of citric favors the formation of a better deposit. The platinum content of the solution may be renewed as it becomes exhausted, but finally the solution ceases to give a smooth deposit. But a small amount of hydrochloric acid revives it by correcting the alkali environment formed at the cathode. The current density has an effect upon the deposit, a low current density gives non-adherent platinum. The effects of various other changes in the conditions are also described.

White Lead.

Mr John V Yunck, of South Orange, N. J., discussed in his paper the electrolytic production of white lead on the basis of experience in a small plant making for several months about 50 lb. of white lead per day, equal to the best for covering and color qualities. The experiments were conducted at the laboratories of the late Rev John B. Tibbits, at Hoosick, N. Y.

The apparatus consisted of a tank about 36 in. high by 24 in. wide and 30 in. long (with glass sides to note the operation). Anodes of lead and cathodes of aluminium were cast in strips and grids connected at top and bottom, to facilitate continuous operation. The tank was water-cooled from the outside and at the same time a stirring device was placed in the bottom of the tank to keep the solution in a slow, steady motion.

Two solutions were used as electrolyte, one a 15 per cent solution of nitrate of soda, the other of nitrate of ammonium. The first was cheapest in first cost, though, in the opinion of the author, ammonium nitrate being a better conductor, it would be cheaper from a commercial standpoint to use it.

During electrolysis carbon dioxide gas was allowed to pass through the electrolyte from small orifices at the lower part of the tank. After running about 2½ hours the operation was stopped for about one-half hour to allow thorough settling, the solution was drawn off and the precipitated white lead was removed, washed and dried. The current density used was 10 amp per square foot anode surface at from 1 volt to 2 volts.

As the electrolyte is made up of sodium and ammonium nitrate in water, and the solution is saturated with free carbon dioxide, the reaction is assumed to be as follows: The solution is decomposed, yielding at the anode nitrogen pentoxide, oxone and oxygen, and at the cathode sodium hydrate, ammonium and hydrogen. The lead is attacked by the powerfully oxidizing pentoxide (N_2O_5) and ozone, since nitrogen pentoxide in the presence of water is decomposed and forms nitric acid (HNO_3).

During the double decomposition which takes place, nitric acid (NHO_3) and hydroxide of lead $Pb(OH)_2$ are formed. The nitric acid combines with the free ammonia and sodium hydrate to again form sodium nitrate, while the plumbic hydrate is precipitated by the free carbon dioxide present and forms finally the hydrated carbonate of lead $2\,PbCO_3 + Pb(OH)_2$. In this way the solution is regenerated and the only materials consumed are lead, carbon dioxide and water.

By this process a white lead was produced finer than can be ground by any mechanical means, and the finer the particles the greater the covering properties. The best commercial white lead contains the greatest amount of water, the amount running up to 2 per cent. This quality is more or less difficult to obtain ordinarily, but in the electrolytic process is very easy.

The question whether the process can be carried out with a profit to the manufacturer is answered by the author in the affirmative. The electrical energy required per ton of white lead is about 16 kw-hours. There is only a loss of water and a small amount of carbon dioxide. The first cost of the plant is said to be very much less than that with the old method; in the latter capital is idle for months, while the electrolytic method can convert metal into carbonate from day to day.

The author refers finally to the production of colors, where the anodes were composed of bimetallic substances, lead in combination with copper, nickel or iron. By this means the author states that colors of the most delicate shades and tints can be produced, of different kinds, with ease. The precipitation being uniform when different electrodes and electrolytes are used, iron-oxide paints of particular richness in texture as well as color are produced this way, and very cheaply.

There were on exhibition various specimens of white lead and colors made by the author in this way. In the discussion Prof. C. F. Burgess expressed a doubt whether it would be possible to maintain continually the originally good condition of the electrolyte. He thought there would be danger of the electrolyte becoming fouled in time so that the desired quality of white lead could not be uniformly maintained.

Western Standard Cell.

Dr. G. A. Hulett, of Princeton University, whose extended researches for a series of years have contributed so much to our knowledge of standard cells, presented in abstract two papers on the Weston cadmium standard cell.

The first paper referred to the e.m.f. of cadmium amalgams

of different concentrations. The second discussed one special point in the thermodynamical theory of the Weston standard cell, namely, the question whether the second form of the Gibbs-Helmholtz equation (including the temperature coefficient) contemplates a change of concentration of the electrodes.

In the discussion Mr. Hering suggested it might be practical to calculate formation heats from electrical measurements. Dr. Hulett replied that the difficulty was in the second term of the Gibbs-Helmholtz equation, being the product of the absolute temperature and the temperature coefficient of the e.m.f. A small mistake in measuring the latter might result in a large mistake in the product.

Electrolytic Reduction of Nitric Acid.

A second paper on this subject (the first paper, see in our Vol. V, page 449) was presented by Dr. Harrison E. Patten and W. J. McCaughey, of the Bureau of Soils, Department of Agriculture, Washington, D. C. The chief conclusions are:

That ammonium sulphate in sulphuric acid solution is oxidized at a platinum anode, nitrogen gas being liberated.

That in the electrolysis of nitrate in sulphuric acid solutions containing copper sulphate, hydroxylamine is formed at copper cathode as an intermediate step in the reduction of the nitrate to ammonia; that nitrogen gas is liberated at the cathode; that the ammonia which diffuses over from the cathode is oxidized at the anode to substances which reduce permanganate; that nitrogen gas is evolved at the platinum anode.

The electrical and chemical and physical conditions under which these changes take place are defined in the paper.

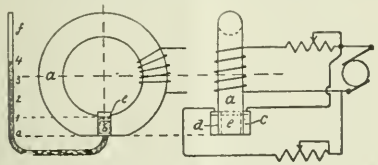
It appears that nitrogen undergoing either oxidization or reduction probably goes through several of the intermediate stages, if not all, which exist between its initial and final state of oxidation.

Electromagnetic Flotation Processes.

A very peculiar and interesting process is described in a paper by Mr. A. P. Steckel dealing with the "electromagnetic separation of non-magnetic, non-conducting substances."

The method described was the result of a study of the problem of obtaining a more thorough concentration of Lake Superior native copper ores, carried out at the Buffalo Smelting Works during the last three years.

As shown, *A* is an electromagnet, in the gap of which is a



PRINCIPLE OF ELECTROMAGNETIC FLOTATION PROCESS.

trough *e* of uniform cross-section made of insulating material and carefully leveled so that a liquid *b* partially filling the trough shall have uniform cross-section. The liquid is water containing a few per cent of sulphuric acid to increase its electrical conductivity. At the ends of the trough, but purposely set somewhat inside the boundaries of the magnetic field, are carbon electrodes, *c* and *d*, accurately fitting the trough and carrying direct current to and from the liquid conductor. The relation between direction of magnetic field and direction of current in the liquid is such that the force brought to bear on the liquid is downward. The object is to adjust at will by this electromagnetic means the apparent specific gravity of the acid solution, while any unmagnetic and non-conducting particles of ore, etc., are not affected.

The attachment *f*, shown in the figure, is a gauge glass for accurately observing the apparent specific gravity of the liquid. Before attempting to use the apparatus in concentrating ore various interesting experiments were performed, pieces of glass and of rock as large as could be accommodated in the trough being floated on the water. On the other hand, wood may be made to sink to the bottom in mercury. If the flow of the current in one direction makes the liquid apparently heavy, then the reversal of the current makes it apparently lighter.

As first constructed the trough was 2 in. wide by 4 in. deep by 15 in. long. Although the performance above described was found possible with a trough of these dimensions, it was not possible to hold the liquid sufficiently quiet to even attempt a treatment of finely divided material. A flotation process, especially if fine particles are to settle, requires a quiet liquid, but the liquid under the conditions described above was far from quiet. At first it was thought that the violent agitation of the liquid was due primarily to the rise of gas bubbles at the electrodes, but after this source of trouble had been eliminated by the use of porous woolen screens near the electrodes, the agitation of the liquid was still quite violent.

There was always a tendency of the liquid to become depressed at the middle of the length of the trough and to rise at the ends with a consequent flow. This agitation could be somewhat overcome by strengthening the magnetic field at the ends.

A mixture of fine particles of copper and rock (15 per cent copper) was then put into the liquid to test the scheme of concentration. The presence of the material increased the general agitation somewhat, but it was also noted that each particle of suspended material had an irregular motion of its own. Although all the large particles of copper went to the bottom and all the large particles of rock stayed at the surface, there was not a satisfactory separation of the fine particles either of copper or of rock; in fact, an assay of the tailings skimmed from the top showed 5 per cent copper, all of which was composed of fine particles of copper not allowed to settle on account of the troublesome agitation.

Under the most favorable conditions, with a perfectly broken mixture of copper and rock assaying about 15 per cent copper, the size of particles of both materials ranging from 0.06 in. to 0.001 in. diameter, the lowest proportion of copper in the tailings ever obtained was about 4 per cent. This poor showing cannot be accounted for by the presence of any great amount of extremely fine copper, for in perfectly still water only a few seconds were required for complete settling of the mixture.

Although the cost of power alone might seem a sufficient reason for abandoning the above scheme without a trial, the author is sure that in the absence of certain unforeseen drawbacks the cost of power would not be prohibitive. The chief trouble is the agitation of the liquid, especially the local agitation in the neighborhood of each suspended particle. Since the current does not pass through the particle there is a little space immediately ahead of and behind such particles in the direction of flow of current in which no current flows. The liquid in these spaces has only ordinary weight with the result that an eddy is formed which tumbles the particles around in an irregular manner.

Saturday Session.

Electrical Nature of Chemical Energy.

A paper by Dr. A. H. Patterson, of the University of North Carolina, referred to the recent paper of Dr. J. E. Mills on the nature and source of chemical energy (our Vol. VI, p. 489). He first sketched briefly the electronic theory according to which atoms are charged or combined with positive or negative electrons. Combination ensues when two or more atoms, carrying unlike charges and coming near enough for the purpose, are pulled closely together by the electrostatic lines of force between their charges and held together tightly in a molecule.

In the case of the formation of water $H + H + O = H_2O$, each of the hydrogen atoms carries one positive electron charge and the oxygen atom two negative electron charges. Dr. Patterson calculates the amount of energy which these charged

atoms represent. The value which he finds by calculation is quite sufficient to account for the heat actually given out in the formation of water and is, moreover, of about the magnitude to be expected. Dr. Patterson thinks, however, that too much importance should not be given to his numerical result.

The hydrogen and oxygen atoms (in a molecule of water) may be considered as coming quite near each other when in combination, near enough to render the molecule electrically neutral, but not near enough to equalize the charges and not near enough to prevent stray lines of force producing a "residual attraction" between the molecules.

Dr. Mills in his paper says: "It is possible that the molecular attraction is merely the residual chemical attraction." The electrical theory would simply substitute the word "electrical" for the word "chemical" above. Dr. Patterson discusses the residual attraction somewhat further, and then speaks of electrical conduction in general, pointing out the fact that "physicists and chemists, reasoning from different viewpoints, often reach practically the same general conclusions, and further that the electrical theory, in spite of certain artificial features, seems to offer the best and clearest idea of the source of chemical energy, the mechanism of chemical combination, ionization, dissociation, etc., and the most rational explanation of the various phenomena of physical science."

The paper was briefly discussed by Dr. Gustavus Hinrichs, who spoke of the relation of the newer theories to older ones and confronted the electronic theory of matter with the chemical idea that matter is finally composed of one single substance.

Alloys of Iron with Arsenic and Bismuth.

A paper by Prof. Charles F. Burgess and James Aston, of the University of Wisconsin, gives an account of an investigation of alloys of pure iron (free from carbon) with arsenic and bismuth. This is part of the extended researches which are being carried out at the University of Wisconsin with iron alloys, made from pure electrolytic iron free from carbon.

It has been noted that the presence of arsenic in acid pickling solutions causes a marked diminution in the rate of attack by the acid, and the idea was suggested that if the presence of arsenic in a corrosive solution protected iron from corrosion by that solution, that the presence of arsenic in the iron itself might increase its durability. To test this possibility, such alloys were made, but they failed to show any marked advantage over iron and steel of ordinary grades in their ability to resist corrosion. From the arsenic alloys prepared primarily for this purpose, test bars were made and subjected to various physical tests.

In determining the magnetic properties of the arsenic alloys, some interesting and unexpected results were obtained, which in turn suggested the advisability of testing the influence of the analogous elements, antimony and bismuth, upon the magnetic quality of iron.

Arsenic, with a temperature of sublimation of 450 deg. C., alloys with iron under conditions where it has passed this temperature long before the fusion of the iron, in practically the proportions of the solid mixtures up to a content of arsenic of 4 per cent. The authors also note the interesting feature that the presence of this large quantity of an element (which when present above 0.25 per cent is most detrimental in its physical effects) imparts to the alloy magnetic qualities excelling those of the purest iron and on a par with the best material on record.

Alloys of antimony with iron seem of little value, forming a difficultly workable product with no apparent value as a magnetic material.

Alloys of bismuth with iron were made with a bismuth content of 1, 2, 4, 6 and 10 per cent and magnetic tests were made. For all tests the curves for a bismuth content of 1.0, 4.0, 6.9 and 10.0 per cent present no features of particular interest, the quality being well below the standard electrolytic iron sample. But for the bismuth content of 2 per cent the curve, while below the standard for values of H of less than 22, at this point crosses the electrolytic iron curve and reaches values of density from 4 to 5 per cent higher throughout the rest of the range.

This series, therefore, presents the somewhat paradoxical condition of the addition of 2 per cent of bismuth, the most diamagnetic element known, improving the already high quality of the pure iron.

The authors refer to the difficulties of making comparisons of magnetic tests with the results of others. Magnetic testing is not on such a basis that data from various sources can be assumed as absolute, and on this account comparisons are apt to be misleading. Finally, they make some remarks on hysteresis tests and electric resistivity measurements.

Bakelite for Chemical and Electrical Purposes.

Dr. L. H. Baekeland presented an elaborate paper on bakelite, containing a great many new points and supplementary to his former paper read before the American Chemical Society and published in our March issue, page 111.

In his former paper he had shown how bakelite C, or the final product, which is a polymerized compound anhydride of a

PRESIDENT-ELECT L. H. BAEKELAND.

phenol-alcohol and methylenglycol, can be produced through indirect synthesis by the action of oxybenzyl alcohol on formaldehyde as well as by direct action of phenols on formaldehyde. The latter method is the more available one for practical purposes and consists in heating, under proper conditions, a mixture of phenols and formaldehyde in presence of a catalytic agent, preferably small amounts of bases or alkaline substances. According to the conditions of operation, the process is carried out in three phases, designated by A, B and C.

A is the "initial product of condensation," produced by elimination of water, and contains probably one or more hydroxyl groups in its molecule.

B is the so-called "intermediate condensation product," a higher anhydride evolved by further elimination of water. C is the polymer of B.

Bakelite C is a hard structureless mass, which may be prepared in transparent or in opaque condition. Its color varies from that of colorless glass to amber color or dark ruby-brown. It is harder than shellac, hard rubber or celluloid, but misses the flexibility of the two latter substances, and this is the main defect.

On the other hand, it withstands all solvents and most chemicals, resists boiling water, steam and superheated steam and oils. Heating does not melt it, nor even soften it to any serious extent. Boiling concentrated sulphuric acid destroys it, so does

concentrated nitric acid, but it withstands dilute sulphuric acid, hydrochloric acid and chlorine.

It can stand temperatures of 300° C. and over. At the temperature of melting glass it chars and carbonizes without entering into fusion. In its final condition it can be sawed, cut, bored and turned on the lathe, but it can no longer be molded for practical purposes. In other words, when it has acquired condition C it is no longer a true plastic, so that all operations of molding or shaping must preferably be carried out in its earlier stages, as described in the former paper in our March issue. In its final stage it is tasteless and odorless and an excellent insulator of heat and electricity.

In cost of production it can very advantageously compete with any known plastic.

For all practical purposes A is used as raw material to start with. The latter is obtained in four varieties, each of which may be preferable according to the special purpose in view. They are: "extra thin liquid A," "liquid A," "dissolved A" and "solid A."

In the different modifications of the bakelite process the aim in view is to produce the final product C, but in as far as C is no longer plastic, all forming, shaping, molding or mixing is carried out in the earlier stages.

This is accomplished either by transforming directly A into C in one single operation, or in other cases, especially in rapid molding processes, it is found more convenient to change A into B, then remove B from the mold and afterward change it into C without the use of a mold. In some other cases the molding or shaping process is started from B and the latter is then changed into C by application of the heat.

Whether stage C is arrived at directly from A or indirectly from B, the quickest result and the best product is obtained by heating at relatively high temperatures, say, 160° C. or over. But as at temperatures above 100° C. A dissociates into gaseous products and causes the resulting mass to be porous and spongy, it is necessary to heat under pressure. Without this precaution the resulting mass will be technically worthless.

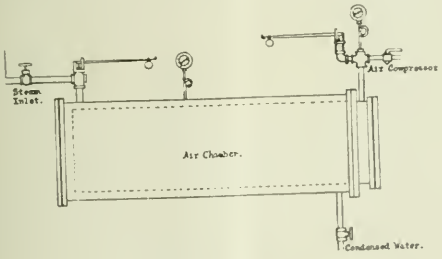


DIAGRAM OF BAKELIZER.

If the heating occurs in closed molds or closed vessels, the so developed internal pressure may be sufficient to counteract the chemical dissociation which causes porosity.

In all other cases the heating should be conducted in a so-called bakelizer, as shown in the adjoining illustration.

This is an apparatus consisting essentially of an inner chamber where the objects are placed and in which, by means of a suitable pump, air can be compressed to 100 lb. or 120 lb. This pressure is maintained during the heating. A steam jacket heats the chamber to a temperature of 140° C. to 180° C., equivalent to about 54 lb. to 150 lb. of steam.

The higher the temperature, the shorter will be the bakelizing process, which converts everything into C.

The different applications of bakelite can be divided summarily into block-working processes, impregnating processes, coating processes and molding processes.

Block Working.—One of the varieties of A may be simply poured into a mold and melted, or first mixed, with pigments, colors or some suitable filling material, like asbestos, clay, mica, wood pulp, graphite, etc. By heating the mass at 140° C. to 180° C. under suitably increased pressure for one to three hours, the whole solidifies to a solid block, which has the exact shape of the container and can easily be removed therefrom because there is a slight shrinkage. If organic fillers are used which are destroyed by too high temperatures, as, for instance, wood-pulp, then the minimum temperatures must be preferred and the time of heating must be increased accordingly. No such restrictions exist for mineral fillers. The so-obtained blocks can now be sawed, cut, turned, polished and shaped in about the same way as ivory or bone is handled.

For large blocks it is preferable to simply continue the heating until stage B is reached and then cut the latter to the proper shape; then B is submitted to further action of heat until it is changed into C.

B, while slightly warm, is soft and somewhat elastic and cuts about as easily as Swiss cheese, yet if heated further it does not liquify nor change its original shape. The transformation of A into B does not need to be carried out under pressure. It may be accomplished simply by heating for a few hours, at temperatures not exceeding 70° C., any of the varieties of A, either in an air-stove or in a water bath.

In order to change B into C it can be heated to proper temperature in a bakelizer as described above. B is no longer attacked by hot water as A is, and for that reason it may be simply heated in an ordinary autoclave containing water in about the same way as rubber is vulcanized for dental purposes, with this difference, however, that higher temperatures should be used than are permissible in the rubber process.

Molds are here entirely superfluous and the objects so treated will retain perfectly their shape. Temperatures of 160° C to 170° C. are quite suitable, but Dr. Backeland has used with impunity temperatures as high as 200° C. and over.

Impregnating Processes.—Liquid A in its extra thin variety is readily absorbed by any porous materials. If a piece of non-resinous soft wood, like basswood or poplar wood, be immersed in extra thin liquid A, after a few hours it will be found that the wood has doubled or even tripled its former weight. The same treatment can be given to unsized paper, paper pulp, cardboard, asbestos, objects of cement or plaster of paris, in fact, to any material of a fibrous, cellular or otherwise porous texture. The impregnated material is now transferred to the bakelizer and submitted there to final treatment. But longer heating is required than under ordinary conditions.

In most instances the impregnated objects have a dull appearance on the surface. This can be easily remedied by applying a second superficial coat of thicker A. The latter is best applied while the objects are still hot; this treatment will impart a very hard and a very glossy surface.

Wood thus treated is not only much harder and stronger, but it has become rot proof, and is a better electrical insulator. It withstands dilute acid solutions and ordinary electrolytes. It can be used to excellent advantage for third-rail covers. Similar usages can be found for impregnated pulp-board, cardboard and asbestos-board.

For the impregnation of **coils for dynamos,** motors and transformers, bakelite represents a ready means to provide these apparatus with a hard and strong insulating mass which cannot soften under the influence of heat, and which withstands temperatures at which all hitherto used gums or resins would melt away.

By the synthesis of bakelite, a certain amount of water is set free and this water must be eliminated from the coils by after-drying. Furthermore, bakelite in its final state C, although very hard and tough, is not flexible; so that any wires or conductors coated with it can no longer stand much bending or twisting, and for such parts the bakelizing operation should only take place after all wires and conductors are in their final place.

With this aim in view, the wire or conductor, provided with its covering of cotton or asbestos, can be simply coated

with dissolved A solution properly diluted with the necessary amount of alcohol, then submitted to spontaneous drying. This may be helped by a gentle application of heat, but never more than is necessary to carry the material to the stage B, so as to maintain the necessary flexibility. The wire is now wound as usual, and in order to insure more flexibility it may be found useful to heat it slightly. Tape or any fabric, or asbestos impregnated with A, may be put between successive layers just as is done when shellac is used as an insulator; after the coil is made up it is now introduced into the bakelizer.

In case the wires are covered exclusively with asbestos it will be advantageous to heat the bakelizer at highest temperatures. However, if cotton or similar organic materials be present, such high temperatures would destroy and carbonize them and it may be safer not to exceed 140° C. After bakelizing, the coils should be submitted to slow drying so as to expel any remaining traces of moisture or solvents, and this operation can be hastened considerably by the use of a vacuum dryer.

In other cases ready-wound coils may be simply impregnated with liquid A, using the precautions as described for the impregnation of wood. Capillary conditions as described for the wood-impregnating process exist here, so that, with some precaution, it is possible to slowly transform A into C or at least into B in an ordinary drying stove, without the absolute necessity of resorting to a bakelizer, always provided the heating be started at temperatures as low as 60° C. to 70° C. and gradually increased to 120° C. to 140° C. In fact, it may be found sufficient not to go beyond B and leave it to future self-heating of the wire when run under overload to arrive at the final condition, C.

As a modification to above methods, the following is suggested: The coil after being properly impregnated may simply be put in an accurately made closed mold and the latter may be filled with more A, using pressure as required, so that after bakelizing same the whole will come out in accurate size and shape and present a much neater appearance than the ordinary clumsy coils now in use for dynamo and motor construction. The very fact that henceforth it is possible to mold coils in regular shapes and most accurate dimensions may ultimately simplify the construction of this class of machinery and render renewals much easier.

Coating Processes.—The simplest way for coating an object with bakelite is to dip it in liquid A and then finish it in the bakelizer. By slightly heating the objects and by using rather thick A the operation becomes rather simple, especially for metallic objects.

Or the A-coated objects may be first heated gently in a stove until the A has been transformed into B and then the object may be transferred to the bakelizer. Several coats may thus be applied in succession until any desired thickness is attained.

Suitable filling materials, as silica or fine sand, clay, slate dust, powdered asbestos, etc., added to liquid A in suitable proportion, will give a putty-like mass which can be easily kneaded, especially if slightly heated; it can be applied and modeled to any kind of surface to the desired thickness and shape.

This same mass can be rolled out in thin sheets and the latter can be applied on the inside or outside of metallic vessels. The whole can be directly finished in the bakelizer or be heated previous at low temperatures so as to bring it first into B state.

This method gives a ready means for covering iron pipe or pumps or similar objects with a layer of protective material and thus render them more suitable for chemical engineering purposes

Thick layers of bakelite without fillers or mixtures containing little filler do not adhere well to metallic surfaces. But by using more filler and specially by using gritty materials, as fillers, like sand or abrasives, the adherence becomes excellent. For instance, mixtures of emery with about 10 to 15 per cent liquid A, can be made so that after bakelizing they will stick to glass to the point that they can no longer be removed unless by chipping off pieces of glass.

A composite coating of bakelite can also be applied on wooden or metallic vessels by first dipping a sheet of asbestos in A, partially transform it into B by heating, then stick it, by means of thick A, to the surface which is intended to be protected, and afterward press it against the surface by means of a hot, smooth plate. The latter operation is finished in about 10 to 15 minutes if the pressing plate is maintained sufficiently hot. By selecting polished metallic pressing plates a very beautiful finish can be obtained at the same time. In this case bakelite not only acts as an impregnating and finishing material, but also as an excellent and permanent adhesive.

A similar method may become useful for lining wooden or metallic boxes with impregnated asbestos so as to make them suitable for electrolizing tanks or storage batteries.

Sheet-iron or stamped boxes provided with a thin coating of bakelite can stand boiling dilute sulphuric acids and boiling neutral solvents.

It should be borne in mind that on account of the limited flexibility of bakelite, such sheets cannot be twisted or bent beyond certain limits without splitting the protective layer. In any such cases where bending has to be done, it must be done before the varnish is applied or after the A has been changed into B, which still leaves some scope for flexibility.

Molding Processes.—The simplest but slowest way for molding bakelite is to pour liquid A, alone or mixed with filler, into suitable molds and heat in a bakelizer. This operation may take as much as one to three hours, according to the temperature or to the size of the object, so that this process has the objection of requiring the relatively long use of molds.

It can be shortened by simply carrying the heating process until the B stage, after which the objects can be expelled from the molds and finished in the bakelizer at any suitable time thereafter and without the further use of molds. The B stage can be obtained by plain, but slow heating in a stove or water bath, or by rapid heating in the bakelizer.

But even all this is too slow for many purposes where quick and accurate molding is essential. It then becomes simpler to mold in a hot press. For this purpose a hydraulic press or a screw press or even a lever press can be used, as long as it is provided with contrivances whereby the plateens can be heated and cooled quickly, either by steam and cold-water circulation, or by gas heating.

Temperatures as high as 200° C. are desirable for rapid and best work, but the molding can be done also at 80-lb. steam pressure. It is a noteworthy fact that molds under high-pressure contact with the plateen heat up and cool quicker than if not under pressure.

The great penetrating power of A makes it possible of making molded objects containing as little as 10 per cent and even less of bakelite, the remainder being made up of suitable fillers, for instance, asbestos. Quantities of 20 to 30 per cent of solid A and 80 to 70 per cent of asbestos make excellent compositions for molded insulators.

In some cases it may be found desirable to increase the amount to about 40 per cent. Wood pulp or ground sawdust requires these larger proportions if the objects have to stand boiling water without losing their gloss.

Molded objects of bakelite in B condition are about as strong as shellac, but they still soften under the influence of heat. They become considerably stronger and acquire their final resistance qualities by being heated in the bakelizer. There is again a slight shrinkage of volume which has to be taken into consideration while designing the molds. This contraction is always the same for the same compositions, and becomes very small if large amounts of fillers are used. By taking these factors into consideration the molding can be done with an accuracy of 0.001 in. or better.

B, although infusible and insoluble, softens when heated

under high pressure and welds and molds together. This enables to still further simplify the molding operation by using ground B instead of A. But it then becomes necessary to use maximum temperatures and highest possible pressure, B not flowing so easily as A. This is specially indispensable when large amounts of filling material are employed. This method of working is decidedly advantageous when a highly polished surface and very accurate molding are desired. By keeping long enough in the mold no after-treatment in the bakelizer is required, and the gloss imparted by a polished mold is thus kept intact. The use of B is also advisable in such instances where mixtures rich in bakelite are desired.

For such molded electric insulators which are expected to stand high temperatures, finely ground asbestos, clay, mica or other similar fillers should be used. Whether bakelite-asbestos or bakelite-mica insulators will answer the purpose for high-voltage insulation as well or worse than porcelain is a matter which experience and the test of time can alone decide.

For insulation in third-rail systems, where continuous vibration of passing trains plays havoc with brittle and unreliable porcelain, bakelite-asbestos has indicated decided superiority after several months of continuous service, as well as by direct laboratory tests; besides greater strength, it has shown more regularity in manufacture and allows more accurate molding, which permits closer designs and smaller margin of safety.

Dr. Baekeland gives in several tables the results of electrical, mechanical and heat tests to prove a decided superiority of bakelite over some excellent insulating compounds.

Dr. Baekeland finally mentions the special mixture of bakelite with graphite. These two materials compound very well together in almost any proportions. Liquid A or solid A can be used for this purpose. By varying the amounts of bakelite these compositions may be made of varying hardness.

He has obtained some very encouraging results by trying to use them for self-lubricating bearings. The fact that such bearings can be molded very accurately at little cost makes their interchangeability and rapid renewal a very easy matter. Dynamos or motors or other revolving machinery where lubrication is a delicate matter might be provided with such bearings instead of the older metallic bearings. Bakelite-graphite bearings will not melt nor soften in case of overheating; they can be used in conjunction with oil like any other bearings, and in case of insufficient supply of oil the graphite present will supply the necessary lubricant.

As a lining for pumps which are required to handle liquids which corrode iron the same mass may find its uses.

But bakelite-graphite composition presents other possibilities from an electrical standpoint, since it gives a means of producing a material of which the electrical resistance can be changed at will in a very wide range by changing the proportion of bakelite.

Graphite Cathode Dish.

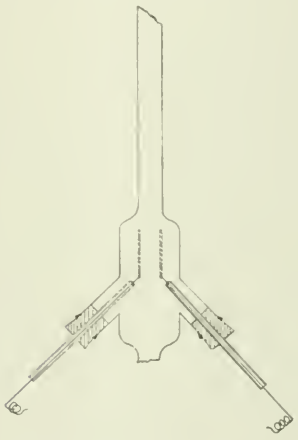
In a paper by Dr. J. W. TURRENTINE, of the Wesleyan University, simple graphite electrodes (paraffined, to overcome the porosity) are described which are designed for use in the place of platinum as insoluble electrodes in electrochemical experiments.

An account is also given of preliminary experiments with a graphite dish intended to supplant in some forms of electrochemical analysis the Classen platinum dish. The dish is recommended for electrochemical separations and for analysis where great accuracy is not required. Confidence is felt that, after it has been further developed, it will be able to entirely take the place of the platinum cathode dish. Details are given of the method of preparation.

Gas Coulometer.

A paper by Dr. J. W. TURRENTINE describes a modified oxyhydrogen gas coulometer. It is a modification of the Walter-Neumann single-tube coulometer. The latter is provided with a leveling bulb, and therefore becomes a direct-reading instrument. This form is especially convenient for all current efficiency experiments when the electrode products are wholly, or in part, gaseous. The leveling bulb makes it possible to read the gas volumes which are to be compared at atmospheric pressure.

The Walter-Neumann coulometer is constructed of a single, upright tube, graduated, with an oblong, bulbous enlargement at its lower end, containing the electrodes, and is surmounted on its upper end by a stop-cock and capillary tube. The lower end is joined by means of a length of rubber tubing to a level-



GAS COULOMETER.

ing bulb. The electrodes are corrugated plates of platinum foil mounted on thin platinum wires, the latter being sealed through the walls of the bulb, and terminated on the outside in small tight coils or loops. Electrical connection is made with the electrodes by hooking wires in these external loops.

The disadvantages of this apparatus are due to the fragility of the terminal wires and the glass seal which holds them. The platinum terminal wires, being thin, are easily bent, and, in spite of care, are soon broken off. This renders the apparatus useless. Further, only poor contact is gotten with the terminal loops by hooking wires in them, yet this is the only means that may be employed for completing the electrical connection. If wires are fastened more securely in the coils, the latter are almost immediately broken off. The poor connections, with resulting imperfect contacts, cause the glass to crack and the tube to leak.

In the modification of Dr. Turrentine the upper part of the Walter-Neumann apparatus is modified only in small details, but the lower, bulbous portion of the main tube has been greatly changed. This bulb is oblong and is 3½ in. in diameter. Instead of the two platinum wires it now carries, sealed in its walls, two side arms, or tubes, opposite each other and at an angle of 45° to the perpendicular or longitudinal axis of the tube. They are made to slope downward at this angle so that gas bubbles, carried into them by convection currents, cannot become lodged. The side arms are made of thin platinum foil and are deeply corrugated to enlarge their surface. They are 1¼ in. x 1½ in. in dimensions and afford an electrode surface of at least 1 sq. in. on each face. Supporting them is a short section of platinum wire, which is sealed in a length of glass tubing of 1.5 in. external diameter and 3 in. long, and which is welded to a piece of insulated copper wire about 1 ft. in length and extending through the tube. The glass tubes are inserted through one-holed rubber stoppers, which fit the side arms.

The construction renders the electrode easily detachable. This is especially desirable when they need cleaning. As the

electrodes are not subjected to much wear, they should have a long life.

Calcium Carbide.

A paper by Profs. S. A. Tucker, W. A. Alexander and H. K. Hudson, of Columbia University, compares the relative efficiency of the arc and resistance furnace for the manufacture of calcium carbide. Theoretically the advantage of the resistance furnace is that the temperature can be regulated and held at a point much below that of the arc. Experiments were made on a small scale in the laboratory and the results are summed up as follows:

In all respects the resistance method is the most efficient. On the average the resistance method was about three times as efficient as the arc method, while the best run of the resistance method was twice as efficient as the best run of the arc method.

In both methods the quality of the yield was mainly influenced by the proportion of coke and lime used in the charge. In the arc method, the best carbide was obtained with a charge of 55 per cent coke and 45 per cent lime. In the resistance method, the best carbide was obtained with a charge of 50 per cent coke and 50 per cent lime.

The time of run influenced the quantity of the yield, but after eight to nine minutes in the arc method and 20 to 22 minutes in the resistance method, under the conditions of the experiments, the increase in the yield was not proportional to the increase in length of run.

The value of the current used in the resistance method influenced the quality of the yield. If the current was too high the carbide was burned, due to excessive heat. In the resistance method the best part of the carbide was found at the bottom of the furnace, while the part directly between the electrodes was somewhat burned. This was due to the fact that the main part of the current passed through this part of the charge and the temperature reached was above that necessary for the formation of calcium carbide. In the arc method the best of the carbide was found at the bottom of the crucible.

An analysis showed that about 20 per cent of the original coke in the charge was burned out of the unconverted charge in the resistance method.

Silicon.

A paper by Mr. C. L. Zimmerman, of the University of Wisconsin, is a very useful summary of our present knowledge of the physical properties of crystalline silicon. Concise data are given of atomic weight, specific gravity, molecular state of aggregation, tenacity, expansion with temperature, tensile strength, hardness, porosity, melting point, vapor tension, specific heat, latent heat of fusion, heat of combustion, thermal conductivity, optical properties, spectrum, magnetic properties, electrical properties, thermo-electric properties, rectifying properties, Hall effect and electrical resistance. As this paper itself is a summary, it is impossible to abstract it briefly.

Calcium Alloys as Reducing Agents.

A paper by Dr. O. P. Watts and E. R. Suhm, of the University of Wisconsin, describes a continuation of the research recorded in our Vol. 6, page 237. On account of the greater reducing action of calcium-magnesium alloys in comparison with aluminum, it had been hoped that it would be possible to obtain fused tungsten and titanium as reduction products. These hopes were not realized.

One of the chief difficulties is the violence of the reaction with calcium-magnesium alloys. This may be effectively overcome by molding a charge of very finely pulverized material into briquets.

It was further found necessary to devise some means of heating the charge considerably above the temperature at which reaction begins, in order that the heat added by the reaction should produce a fluid slag and a good separation of metal. A number of experiments made are described and the results are summed up as follows:

The direct comparison of aluminum with calcium-magnesium aluminum alloys as reducing agents gave conflicting results. In the reduction of a mixture of MnO_2 and TiO_2 aluminum was superior, while in reducing Mn_3O_4 the alloy gave far better results. It is probable that the alloys are superior in all cases where none of the charge is blown out of the crucible. The alloys are distinctly superior to aluminum for the igniting mixture.

As noted above, attempts were made to supply enough heat to secure solid masses of tungsten and titanium, either by rapidly heating a charged crucible in a resistance furnace, or by heating with an arc of 50-60 kw, or by feeding the charge into a mass of melted oxides, or by adding BaO_2 and extra alloys to the charge. But all these methods failed.

The vaporization of MoO_2 can be prevented by getting it into combination with other oxides before an extremely high temperature is attained.

Since the violence of reaction of the alloys increases with the amounts of calcium and magnesium, the most serviceable as well as the cheapest alloys will probably be those with only enough calcium or magnesium to be readily pulverized.

Protection of Steel Against Corrosion.

A paper by Mr. Maximilian Toch emphasizes that oxidation cannot take place, under any circumstances, in the absence of moisture, as the addition of water is a necessary element in the composition of ferric hydroxide, hence the necessity to coat steel which is surrounded by either ordinary fireproof masonry or embedded in concrete, with a material which shall have electric insulating qualities and moisture-resisting qualities, rather than inhibitive qualities for the inhibition is merely secondary and the primary cause of the corrosive effect is water itself.

Much is said of the protective quality of concrete, but concrete as it is generally used contains rarely more than 15 per cent of cement, and cement is the real protective agent in the prevention of corrosion. The concrete mixture is either composed of 1:2:4 or 1:3:5, the third number representing the aggregate, which is largely composed of broken stone. The physical characteristics of the materials used preclude the possibility of a dense concrete, and the voids which are adjacent to the steel itself are largely the cause of rust-producing agents.

A perfect coating of insulating material should be given the steel, rather than a perfect coating of such paint as shall itself be affected by moisture and be decomposed by moderate alkalies. It is necessary to use alkali-proof material. A carbon-black paint when mixed with linseed oil forms practically no protection for steel which is to be surrounded by alkaline and wet masonry of any kind. If a beam is coated with linseed-oil paint and then covered with an inch of cement mortar, a driving rain will go through such a wall and carry with it sufficient solvent salts to disintegrate the paint and leave a space between the steel and the concrete, and once corrosion starts in a place of this kind, it will proceed.

Rapid Electrochemical Analysis.

In a paper by Messrs. L. S. Palmer and R. C. Palmer, of the University of Missouri, reference is made to the various devices which have been employed in recent years for rapid electro-analysis, such as rotating the cathode, rotating the anode, and lately even rotating the electrolyte. Some experiments on the determination of copper with the apparatus of Frary (*Jour.*, Am. Chem. Soc'y, Vol. 29, page 1592, 1907), in which the electrolyte is rotated and the electrodes are stationary, led the present authors to believe that the speed with which complete deposition was obtained was not wholly accounted for by the fact that the electrolyte rotated, but depended to a large extent upon the nature of the electrodes. The anode used in the Frary apparatus is a platinum spiral of about 1 mm diameter; the cathode a platinum gauze, weight about 14 grams, 15 mesh to 1 cm, size 11 cm x 5 cm.

To test this supposition the present authors conducted a

series of tests to determine the relative merits of the two factors—gauze cathode and rotating electrolyte in rapid depositions. Three comparative sets of tests were, therefore, made: one with a rotating electrolyte using the gauze cathode; a second set without rotation of electrolyte using a gauze cathode, and for comparison a series using the usual form of platinum cone as cathode, without rotation of the electrolyte.

In one of the most interesting runs 0.31 gram of copper was completely deposited on the gauze cathode in 25 minutes with magnetic rotation of the electrolyte, in 50 minutes without rotation, and in five hours using the platinum-cone cathode. It seems from this that the rapidity of Frary's method is due, in a large measure, to the gauze cathode.

The conclusion of the authors is that the efficiency of the gauze cathode, thus shown, warrants its use alone for simple, rapid determinations, thus dispensing with the various mechanical devices for agitation of the electrolyte.

Soil Analysis.

A paper by Dr. F. K. CAMERON, of the Department of Agriculture, Washington, discussed electrochemical methods of soil analysis. He suggested that the greatest weathering agent in nature is plain solution in water. His methods of analysis is essentially a measurement of resistance by a Wheatstone-bridge method.

Corrosion.

A brief paper, by Mr. WM. ROY MOTT, of the University of Wisconsin, discussed the "overvoltage" as a factor in the corrosion of metals. Hydrogen requires different voltages for its separation on different electrodes and on this, in part, depends the amount of local current that flows in the corrosion of metals. Some old data on the corrosion of zinc is shown to be qualitatively and quantitatively explained by observed data on overvoltage.

Tubular Conductors.

The last paper of the meeting was presented by Mr. C. I. ZIMMERMAN on concentric tubular conductors for heavy currents, instead of busbars. He suggested the use of concentric conducting tubes, the inner shell of the inner tube and the outer shell of the outer tube to be water-cooled.

Mr. Carl Hering then moved a vote of thanks to the local committee and all who had contributed to the success of the meeting. The convention then adjourned, Dr. Backeland as the new president making a felicitous little speech.

The next meeting will be held in October in New York.

* * *

All the weekly technical papers interested in the fields covered by the American Electrochemical Society have already published extended and highly appreciative reports on the meeting, especially *Electrical World*, *Electrical Review and Western Electrician*, and *Iron Age*. But the most interesting remarks appeared probably in *The Iron Trade Review*, of Cleveland, who published not only an editorial on the "significance of a successful convention," with special reference to the symposium of papers on the electrometallurgy of iron and steel, but also another editorial entitled "The Decadence of Some Technical Societies," beginning as follows: "There have been numerous references of late to the ossification which seems to set in with certain old-established societies formed in the first instance for the interchange and dissemination of technical knowledge." Specific reference is then made to the recent Washington meeting of a large engineering society of this country. The editorial concludes as follows: "In striking contrast with the Washington meeting was that of the younger organization, the American Electrochemical Society."

"Another organization which always does good work at its meetings is the American Society for Testing Materials. Both of these societies are fortunate in having able and wise presidents and secretaries."

In the following we give a complete alphabetical list of all the members and guests who registered at the meeting:

Dr. and Mrs. Ed. G. Acheson, Niagara Falls, Ont.; Edward G. Acheson, Jr., Niagara Falls, N. Y.; R. W. Acheson, Niagara Falls, N. Y.; Chas. E. Acker, New York City; R. C. Acott, Niagara Falls, N. Y.; G. F. Ahlbrandt, Middletown, Ohio; H. G. Akers, Toronto, Canada; F. Albright, Buffalo, N. Y.; Thomas B. Allen, Niagara Falls, N. Y.; Mr. and Mrs. W. H. Arison, Niagara Falls, N. Y.; Miss Arison, Niagara Falls, N. Y.; H. L. Arnold, Pittsburg, Pa.; James Aston, Madison, Wis.; L. H. Backeland, Yonkers, N. Y.; J. Watson Bain, Toronto, Canada; F. H. Banbury, Niagara Falls, N. Y.; Wilder D. Bancroft, Ithaca, N. Y.; W. P. Barba, Philadelphia, Pa.; George T. Barker, Niagara Falls, N. Y.; J. B. Barned, New York City; A. Barton, Toronto, Ont.; Mr. and Mrs. P. L. Barton, Niagara Falls, N. Y.; Joseph F. Becker, Brooklyn, N. Y.; Fred M. Becket, Niagara Falls, N. Y.; John W. Beckman, Niagara Falls, Canada; Howard C. Beltz, Hornell, N. Y.; P. McN. Bennie, Niagara Falls, N. Y.; S. D. Benoliel, Philadelphia, Pa.; E. R. Berry, Boston, Mass.; E. Blough, Pittsburg, Pa.; H. A. Boyd, Buffalo, N. Y.; Wm. Brady, S. Chicago, Ill.; Harry L. Brinker, Youngstown, Ohio; J. W. Brown, Cleveland, Ohio; C. F. Burgess, Madison, Wis.; E. C. Butler, Niagara Falls, N. Y.; J. R. Cain, Washington, D. C.; G. H. Calkins, Buffalo, N. Y.; F. D. Carney, Steelton, Pa.; C. F. Carrie, Jr., Elmira, N. Y.; E. B. Carter; Hector R. Carveth, Niagara Falls, N. Y.; C. R. Cary, Philadelphia, Pa.; Adolph Chalas, Paris, France; D. H. Childs, Niagara Falls, N. Y.; Camillo C. Cito, Givington, N. J.; R. H. Clayton, Manchester, England; W. F. Clymer, Cleveland, Ohio; Jesse Coates, Coatesville, Pa.; Frank N. Coe, Niagara Falls, N. Y.; H. B. Cohn, New York City; Edward A. Colby, Newark, N. J.; E. P. Coleman, Buffalo, N. Y.; W. Collier, Toronto, Ont.; Charles Colne, New York City; J. Converse, Niagara Falls, Canada; Mr. and Mrs. H. J. Corvil, Niagara Falls, Ont.; L. B. Coulter, Niagara Falls, N. Y.; Mr. and Mrs. Alfred H. Cowles, Lockport, N. Y.; G. E. Cox, Niagara Falls, N. Y.; Fred. Crabtree, Pittsburg, Pa.; W. S. Crafts, Cleveland, Ohio; Chas. Crew, New York City; H. C. Cridland, Dayton, Ohio; R. Cuchens, Niagara Falls, N. Y.; F. M. de Beers, Chicago, Ill.; E. L. Diehl, Pittsburg, Pa.; H. H. Doro, Midland, Mich.; E. L. Doty, Buffalo, N. Y.; J. C. Downs, Niagara Falls, N. Y.; Hugo Du Bois, New York City; W. L. Dudley, Nashville, Tenn.; O. E. Dunlap, Niagara Falls, N. Y.; Mr. and Mrs. F. I. du Pont, Wilmington, Del.; Mr. and Mrs. Irene du Pont, Wilmington, Del.; J. A. Durfee, Chardon, Ohio; S. Dushman, Toronto, Canada; J. R. Edmands, New York City; Theo. W. Elliott, Mr. and Mrs. J. W. Evans, Belleville, Ont.; E. S. W. Farnham, Philadelphia, Pa.; F. A. J. FitzGerald, Niagara Falls, N. Y.; Chas. E. Foster, Rochester, N. Y.; E. Fowler, Niagara Falls, N. Y.; Dr. S. Frank, New York City; Eugene Friedmann, Braddock, Pa.; G. C. Furness, Niagara Falls, N. 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Y.; Mr. and Mrs. A. H. Hooker, Niagara Falls, N. Y.; Henry Howard, Boston, Mass.; I. E. Howard, Chicago, Ill.; G. A. Hulett, Princeton, N. J.; Mrs. M. L. Hutchinson, Cincinnati, Ohio; E. J. Hutchinson, Cincinnati, Ohio; O. S. James, Toronto, Canada; Rees James, Munhall, Pa.; D. J. Jenkins, Syracuse, N. Y.; Frederick A. Johnson, New York City; A. B. Jones, Niagara Falls, N. Y.; Phil. H. Jordan, Cleveland, Ohio; B. Katsura, Tokio, Japan; E. J. Kenny, Johnstown, Pa.; H. M. Kellogg, Niagara Falls, N. Y.; P. O. Kerr, Pittsburg, Pa.; E. D. Kingsley, New York City; C. Kirchhoff, New York City; K. Knudsen, Brooklyn, N. Y.; Wm. Koehler, Cleveland, Ohio; E. F. Lake, New York City; W. E. Lambert, Niagara Falls, N. Y.; F. M. Lane, Cleveland, Ohio; Horace W. Lash, Cleveland, Ohio; H. Hughart Laughlin, Pittsburg, Pa.; J. D. Lewis, Braddock, Pa.; F. A. Lidbury, Niagara Falls, N. Y.; A. T. Lincoln, Troy, N. Y.; E. S. Lincoln, Boston, Mass.; Mrs. E. S. Lincoln, Brookline, Mass.; Henry B. 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Richards, South Bethlehem, Pa.; Miss Florence M. Richards, Philadelphia, Pa.; Miss M. Ellen Richards, Philadelphia, Pa.; Wm. A. Rotchburg, Niagara Falls, N. Y.; Hugh Rodman, Pittsburg, Pa.; F. F. Rocher, New York City; Ashmead G. Rogers, Niagara Falls, N. Y.; W. Ross, Lockport, N. Y.; Louis Ruhl, New York City; Henry F. K. Ruppel, Boston, Mass.; Mr and Mrs. C. J. Russell, Philadelphia, Pa.; Pedro G. Salom, Philadelphia, Pa.; Mr and Mrs. I. F. Saunders, Niagara Falls, N. Y.; Carl G. Schussler-berg, Pittsburg, Pa.; Henry F. Schmul, New York City; Edw. E. Schneider, Niagara Falls, N. Y.; W. H. Scott, Syracuse, N. Y.; J. A. Seede, Schenectady, N. Y.; Mr and Mrs. E. M. Sergeant, Niagara

Falls, N. Y.; Mr. and Mrs. G. W. Sergeant, Reading, Pa.; S. N. Sharples, Boston, Mass.; H. F. Sill, Pittsburgh, Pa.; A. S. Simmers, Niagara Falls, N. Y.; Louis Simpson, Ottawa, Can.; V. Skillman, Ithaca N. Y.; Chas. V. Slocum, Pittsburg, Pa.; A. W. Smith, Cleveland, Ohio; Edmund F. Smith, Niagara Falls, N. Y.; Mr. and Mrs. Wm. A. Smith, Niagara Falls, N. Y.; E. C. Smith, Niagara Falls, N. Y.; W. L. Spalding, Buffalo, N. Y.; Mr. and Mrs. E. C. Speiden, New York City; E. A. Sperry, New York City; Mr. and Mrs. E. C. Sprague, Niagara Falls, N. Y.; F. A. Stamps, Niagara Falls, N. Y.; A. Stansfield, Montreal, Can.; Cav. Ernesto Stassano, Turin, Italy; R. H. Stevens, Munhall, Pa.; Aug. Stillesen, Niagara Falls, Ont.; Mr. and Mrs. G. W. Stone, Niagara Falls, N. Y.; C. J. Strosacker, Midland, Mich.; Wm. Theophilus Stuart, Toronto, Canada; J. L. Stuart, Toronto, Canada; O. M. Sturgess, Buffalo, N. Y.; Dr. and Mrs. J. Takamine, New York City; Chas. E. Taylor, Penn Yan, N. Y.; Mr. and Mrs. E. R. Taylor, Penn Yan, N. Y.; Miss F. B. Taylor, Penn Yan, N. Y.; B. F. Thomas, Chattanooga, Tenn.; J. P. Tindall, Toronto, Ont.; James Tinlin, New York City; Mr. and Mrs. F. J. Tone, Niagara Falls, N. Y.; S. A. Tucker, New York City; T. E. Tynes, Buffalo, N. Y.; C. A. Tyron, Niagara Falls, N. Y.; W. H. Van Winekel, Toronto, Ont.; Mr. and Mrs. C. F. Vaughn, Niagara Falls, N. Y.; F. K. Vial, Chicago, Ill.; Anthony Victorin, New York City; Mr. and Mrs. Alois von Isakovics, Monticello, N. Y.; Mr. and Mrs. S. S. Wales, Munhall, Pa.; Walter Wallace, Niagara Falls, N. Y.; Louis E. Ward, Midland, Mich.; Tracy D. Warring, Perth Amboy, N. J.; G. B. Waterhouse, Yonkers, N. Y.; Oliver P. Watts, Madison, Wis.; F. B. Weaver, Buffalo, N. Y.; R. F. Webber, Niagara Falls, N. Y.; Fred. B. Wheeler, Syracuse, N. Y.; Mr. and Mrs. E. H. Whitlock, Cleveland, Ohio; W. R. Whitney, Schenectady, N. Y.; B. Wiley, Pittsburg, Pa.; A. M. Williamson, Niagara Falls, N. Y.; T. Ratray Wilson, Niagara Falls, N. Y.; Wm. S. Weeden, Wilmington, Del.; A. L. Woodworth, Sparrows Point, Md.; W. J. Woolridge, Pittsfield, Mass.; Mr. and Mrs. J. A. Yunck, South Orange, N. J.; Miss Agnes Yunck, South Orange N. J.; Edward Zaremba, Chicago, Ill.; C. I. Zimmerman, Madison, Wis.; F. Zimmerman, Newark, N. J.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent)

The Faraday Society.

At the meeting on March 30 the paper by Messrs. E. Salersky and E. Adler on "A New Electrical Hardening Furnace" (published in the May issue of this journal, page 203), evolved an animated discussion.

Mr. F. W. Harbord (communicated) said he had used the authors' furnace at the British Westinghouse Company's works for heating a large amount of steel articles at temperatures varying from 800° C. to 1230° C. with most satisfactory results. His purposes demanded not only such temperatures, but also their continuance for considerable periods without variation or oxidation. At over 1200° C. there was no difficulty in confining the variation to 20° C. or 30° C. He enclosed his steel article in a carefully luted iron box to avoid contact with the fused salt, but some bars heated for a long time in contact with the bath gave no evidence of deleterious action. He considered that the entire freedom from oxidation and the ease and regularity of the control of temperature made this furnace exceptionally valuable; and if a furnace could be designed to compete commercially with large heating furnaces great possibilities were in view. Freedom from oxidation was one of the most important modern requirements.

Mr. W. Rosenhain (communicated) was of the opinion that the furnace offered decided advantages for the hardening and tempering of steel tools. Protection from oxidation was a valuable feature, but the choice of salts demanded care. The authors quoted a bath of mixed nitrates of sodium and potassium, and this would be strongly oxidizing. The action of chlorides or fluorides at high temperatures would not be so serious, but the effect on the properties of steel due to exposure to these salts had not yet been ascertained. The rapidity of heating obtainable by electric furnace was sometimes advantages, but very rapid heating of metal of uneven cross-section set up expansion stresses, especially if the steel had already been hardened, and risk of causing cracks might arise from the use of this furnace in some cases. Gradual heating up was in many operations a decided advantage and safeguard. The uniformity of temperature obtained was remarkable, but that was largely a matter of sufficient lagging. This type of furnace opened up the question whether heating to such temperatures as would certainly be injurious where the metal is exposed to an ordinary furnace atmosphere, would still be prejudicial when the metal is submerged in fused salts, and some recent experiences seemed to indicate that there was a great difference. Experimenters should be cautious. The effects of heat treatment by the two different methods might be found to differ fundamentally.

Mr. C. R. Darling (communicated) thought that the authors' claim of greater speed and more equable distribution of temperature for the furnace appeared fully established, but he was not satisfied with the statement of the cost of working. He quoted figures, charging gas at 3s. 6d. per 1000 cu. ft. and electricty at ½ pence per B.t.u., to show that the respective totals would be £3 8 1 for gas furnaces and £2 18 6 for electricity as representing the average conditions in this country. But in large works where producer gas was available the financial superiority of the electric furnace would completely disappear. In view of the difficulty arising from corrosion of the pyrometer sheaths by fused salts, he advocated the substitution of a radiation or an optical pyrometer at temperatures above 1000° C.

Mr. T. Vaughan Hughes (communicated) was of opinion that in the application of a bath of liquid salts for some steel tools the authors were adopting a course fraught with many practical difficulties. He said this on the authority of statements made to him by manufacturers who had given such furnaces extended practical trials and compared them with recent producer-gas fired equipments. The drawbacks are: too sudden heating of the tools; the absence of any current of gas to sweep away occluded gases; the nuisance produced by the salts used, and the inadequacy of the method of dealing with the large quantity of goods. It seemed that the efficiency of the furnace is low in comparison with others now in daily use. It required 20 kw to maintain a temperature of 850° C., as compared with 3 kw per cubic foot in a carborundum furnace at about 1800° C. He quoted particulars and figures of gas-heated furnaces, all in one block, and contended that the cost of the authors' furnace would be about £288 per annum for current as against £208 for fuel and steam in his own patent furnace, in which large trays containing perhaps 100 articles are heated at one time and at a rate which practical experience has proved to give the best mechanical results, and all sorts of complicated steel articles are heated evenly without distortion and without the aid of any pre-heating furnace, as recommended by the authors.

Mr. W. C. Prebble remarked that if tools and similar articles were raised quickly to the temperature of the bath, distortion was likely to ensue, particularly in the case of complicated tools.

Dr. J. A. Harker agreed with Mr. Rosenhain's objection to the use of nitrates in the bath. His experience was that the sharp points and edges of tools were spoilt my surface oxidation, and he considered that the amount of energy consumed by the furnace was unnecessarily large. He referred to an electric furnace at the National Physical Laboratory in which the consumption of energy had been reduced from 3½ kw to 1½ kw., although the heated space was larger than the authors' No. 1 size. The improvement was due to care taken in the lagging, and he recommended this point to the authors' consideration. On heating up, much more than the normal amount of current would be required, and the method of using an auxiliary carbon electrode seemed to him to introduce difficulties. It was possible to get very uniform temperatures in a furnace without stirring by means of a system of vertical tubes cross-connected.

Dr. C. H. Desch was of opinion that the furnace was well-constructed, quite suitable for hardening steels, and adapted to overcome the difficulty of carrying out this operation, by means of skilled observation with the eyes, for a pyrometer was useless in an ordinary muffle.

Mr. Charles Weiss said that the statement of costs in the appendix seemed to him to unduly penalize gas as compared with electricity. Where only a direct current was available there must be the trouble and cost of transformation.

The chairman remarked that the amount of electrical action likely to occur would be dependent to some extent on the form

of the current wave. Electrolysis might occasionally be advantageous.

Mr. E. A. Adler, in reply, stated that the rate of heating was regulated by the voltage and could be easily controlled. Dr. Harker's statement as to the effects of lagging were very interesting, and he wished to know whether those effects were due to the material or to its thickness. There was no difficulty in starting the bath. The initial voltage was only about 70, and gradually fell to 30. The unequal surface of the auxiliary carbon rod caused sparks which fused the salts locally, and it took only a few minutes to bridge across the bath with a strip of molten salt, and only 15 to 20 minutes to melt the whole. He had used optical pyrometers and found them less suitable than thermocouples, but above 1400° C. the optical instrument might be useful. Mr. Hughes admitted the scientific superiority of the furnace, but did not think such accuracy was necessary for industrial work. With oil-cooled transformers transformation presented no difficulties. Large furnaces would be correspondingly more efficient.

Corrosion of Steel.

In a paper read before the Society of Chemical Industry Mr. G. Nevill Huntley said that not only the effect of carbon dioxide, but also that of sulphur must be taken into account, as instanced by a stand-by boiler in which large blisters occurred, varying in size up to 30 mm in diameter, the bulk of them being in the neighborhood of the water level. On pricking the blisters each was found to contain a certain liquid with a fine black powder in suspension, and a grit was forming in the center of each blister. The liquid was strongly acid to litmus and consisted of a solution of ferrous sulphate, with a slight excess of sulphuric acid, either free or possibly ferric sulphate. The boiler water was slightly alkaline.

Mr. Huntley summed up by saying that in the periods of rest of the boiler, the oxides deposit on the spot where they are formed, giving a coherent membrane, which admits oxygen and not alkali, which accounts for the acid corrosion going on inside an alkaline water.

The author pointed out that streaks of sulphide in the steel may account for this action, and that sulphur in iron combined as manganese sulphide is not as harmless as formerly supposed. He added that these blisters were entirely stopped by the substitution of an alkaline arsenite for caustic soda in the boiler water.

According to a paper of Mr. Edward Crave (Stockton-on-Tees), there are three principal theories: First, the carbonic acid theory; second, the peroxide theory, and, third, the electrolytic theory. There is also a bacterial theory, which is, however, open to question.

Corrosion may take place imperceptibly or with great rapidity and the corrodibility of steel is affected by the presence of alloys. Aluminium, manganese, antimony and arsenic when alloyed with iron or steel are said to increase the liability to corrosion, while nickel, cobalt, tin, copper, chromium and phosphorus decrease this liability.

As the results of some tests carried out by Mr. S. Saniter on ordinary ship steel and steel containing 3½ per cent of nickel dipped continually into sea water, the protection afforded by even this high percentage of nickel is so very slight as to be quite negligible. The amount of copper in commercial steels exerts practically no beneficial influence. Phosphorus, however, is a powerful antidote, but it would appear that no constituent alloyed with iron will give suitable protection against corrosion. The only method, therefore, is to apply a protective covering.

When paint has been applied over the mill bloom on the plates of a ship, in a few months the scale peels off with the paint attached in more or less large patches. If, when the whole of the scale has come off, the ship or structure is thoroughly cleaned of all traces of corrosion and then painted, the protection will, in all probability be permanent, but if any rust is left on the steel, corrosion will continue beneath the skin of paint.

The protective covering of ship plates is, however, liable to damage by rubbing against dock walls. Some waters cause very rapid corrosion of the plates of a ship, and petroleum floating on the water causes the paint near the water line to become soft and slimy and easily detachable. Corrosion takes place more readily at the widest part of the ship, while rivets have been found to be more liable to corrode than the steel plates themselves.

Experience shows that after a ship has been dry docked and properly cleaned and painted there is no further corrosion, and that the identification marks which are put on the plates at the works are always intact, no corrosion taking place upon the surface covered by these marks, which are made with white lead thinned with turpentine and put on while the plate is still hot from the rolls.

The following methods are suggested for protecting steel. (1) Painting while hot and before moisture has penetrated the scale; (2) removal of scale by pickling before painting; (3) exposure without paint until all scale is detached, carefully cleansing and painting; (4) coating the steel work with Portland cement, this latter forming the most perfect covering.

London, May, 1909.

RECENT METALLURGICAL PATENTS.

Nickel and Nickel-Steel

Nickel-Steel From Nickel-Iron Ore.—The immense deposits of iron pyrites, containing nickel and copper, in Ontario, have formed a very attractive problem for metallurgists for a series of years. They have chiefly been worked for nickel and in the past it has been the practice in producing nickel to throw away the usual large quantity of iron in the ore, as completely as possible with not too great a loss of nickel, the aim being to make as pure a nickel as possible. The nickel-copper matte obtained in the usual treatment is separated by the Orford process (though the electrolytic process of D. H. Browne has also proven successful on a commercial scale). A radically different process has now been devised by Mr. Anson G. Betts, who has already revolutionized lead refining. If his new process turns out a commercial success, it would mean an even greater revolution in nickel-steel manufacture. The fundamental idea of the process of Betts is to roast the sulphide ore into a nickel iron alloy, containing any copper or precious metal of the ore, and to electrolytically refine the alloy, for the production of purified nickel-iron cathodes, which may then be converted into high-grade nickel-steel by melting with the proper additions. "Nickel-iron alloys can be refined in a similar manner to the electrolytic refining of nickel or iron alone, depositing on the cathodes nickel-iron alloy. Copper, silver, gold, platinum, etc., in the crude alloy remains as an anode slime, from which the valuable metals may be readily recovered." There is a tendency to deposit an alloy with about three parts of iron to one part of nickel, if the solution contains plenty of each metal, and if it is in motion. In view of Mr. Betts' previous success, his new process, the success of which would create a very large new electrolytic industry, deserves careful attention. If the metallurgical and mechanical difficulties which are involved in every new process can be overcome, the process appears to be quite an attractive financial proposition. (923,005, May 25.)

Treatment of Nickel-Copper Pyrrhotite.—The same metallurgical problem is the subject of a patent by Mr. F. R. Carpenter, who also endeavors to save the iron by proceeding as follows: The pyrrhotite, carrying copper and nickel is freed from the accompanying gangue, then crushed, and given an oxidizing roast, whereby nickel and iron are oxidized and the copper remains unchanged, while the sulphur passes off as sulphur dioxide. The product of this roast is then treated by the Longmaid-Henderson process, i.e., it is mixed with a proper percentage of common salt and given a chloridizing roast and then the chloridized copper leached, preferably with hot water.

from the remaining ore. If the operation has been properly conducted, at least 95 per cent of the copper and little or no nickel may be extracted with hot water from the residues which are now essentially the purple iron ore, or "blue billy" of commerce save that these residues will carry practically all the original nickel and little, or no, copper. The small percentage of the original copper which may not be extracted by hot water because in the form of oxides may be recovered by leaching with a weak solution of hydrochloric acid, which may also dissolve a little nickel, but which can be recovered with the dissolved copper. In extreme cases this loss of nickel is found to be small in amount. The principle of the process depends upon the fact that when the three metals—copper as sulfide and nickel and iron as oxides—are given a chloridizing roast, copper is chloridized and nickel and iron remain unchanged, and the copper is thus made soluble in water. "This process is one of such accuracy that not more than one-tenth of 1 per cent sulphur will remain in the residue." After this treatment the nickel-iron residue is smelted directly with or without other iron ores, but with proper fluxes for ferronickel or made into nickel-steel. (922,388, May 18.)

Steel

Calcium-Silicon Alloy for Steel Refining.—In connection with the article of Dr Hans Goldschmidt in our Vol. VI, page 244, on "calcium silicide for the purification of metals, particularly steel," his recent patent for the preparation of a calcium-silicon alloy is interesting. Two parts, by weight, of lime are mixed with one part, by weight, of silicon and the mixture is heated to about the melting point of cast iron. The lime is in this way partially reduced and the liberated calcium forms with the silicon a calcium-silicon alloy, while the remainder of the lime forms a slag with the silicon. This liquid slag may be regulated so that it crumbles on cooling and thereby enables the easy separation of the calcium-silicon alloy. To aid this crumbling action a flux, such as fluorspar, is preferably added. If two parts of lime are treated with one part of silicon there results a calcium-silicon alloy which contains about 40 per cent of calcium and is free from carbon. These new alloys are used for aluminothermic purposes and the calcium-silicon alloy is especially useful also for the purpose of refining fused steel. The new alloys are specially adapted for this latter purpose on account of their freedom from carbon, thereby preventing carbon from being newly introduced into the fused steel. Further, the calcium-silicon alloy has the effect of removing the last traces of sulphur which may still be present in the fused steel. The calcium alloy, according to the present invention, has also the action of "killing" the steel and it forms a very fluid slag, which soon mounts to the surface. (921,607, May 11.)

Welding

Autogenous Welding of Aluminium.—In our last two issues we published two articles by Mr. M. U. Schoop on his process of autogenous welding of aluminium plates, wires, sheets, castings, etc., by means of the oxy-acetylene or oxy-hydrogen flame and a special flux. The flux serves no other purpose but to reduce the invisible oxide film always present on the surface of metallic aluminium. This flux, if present, prevents successful welding. But by dissolving this film the flux permits the two parts of aluminium to flow freely together and make a perfect joint. This flux, which is the feature of the whole process, is the object of a recent patent of Mr. Schoop. For use with the oxy acetylene flame he usese a mixture, by weight, of potassium chloride, 60 parts; sodium chloride, 12 parts, potassium bisulphate, 4 parts; lithium chloride, 20 parts. This mixture is fused in a platinum dish, then crushed in a mortar and sufficient water added to form a thin paste. If a blow-pipe flame of lower temperature than that produced by the oxy-acetylene flame be employed, such, for instance, as that produced by oxygen and illuminating gas, or oxygen and hydrogen, it is desirable to increase the proportion of potassium bisulphate in order to lower the point of fusion of the mixture. The action of the flux is dual: Firstly, its effect is that of dissolving the aluminium or thin films of aluminium oxide that are formed, and, secondly, it protects the hot metallic surfaces from the air, so that in this respect it plays a part analogous to that of borax in ordinary soldering operations, and what is of importance is that the melting point of the flux is near the melting point of aluminium. In carrying out the process in actual practice, the dissolving substance is applied to the surface to be soldered in the form of a paste or a powder and the surfaces are heated by means of a blow-pipe until they are fused, immediately after which the fusion of the aluminium itself commences, the melting point of the flux being slightly below that of the aluminium. The flux itself does not enter into the joint so that the process is a true autogenous welding process. (922,523, May 25, 1909.)

Acid-Proof Tanks

Tank for Metal Refining.—The construction of a tank for the electrolytic refining of metals, but evidently of wider practical usefulness, is described in a recent patent of Mr. Anson G. Betts. A tank is first made of concrete or cement in the usual manner and the same may be reinforced if desired, particularly for large tanks. After the concrete or cement is well set, the tank is dried and then submerged in a large pot containing melted sulphur, best near the melting point. Great volumes of steam come off as the tank warms up and all air in the pores of the tank is quickly removed thereby. The temperature is then gradually raised for a number of hours, say, 12 hours, for a tank with 4-in. to 6-in. walls, to a maximum temperature of, say, 155° C., or any higher temperature desired. After the evolution of steam at the maximum temperature has practically ceased, the sulphur is slowly cooled to near the melting point again during a number of hours. The reabsorption of the steam remaining in the pores, or its contraction, produces a vacuum into which the sulphur flows, filling the pores at least near the surface, where a filling is most desired. The tank is then taken out, cooled to a little below the melting point of sulphur, and lined with sulphur as follows: The tank is placed flat on its respective sides, ends and bottom and a thin layer of sulphur poured on and allowed to solidify, thereby providing a lining of sulphur. The concrete or cement so treated, but without this lining, resists acids excellently, but the said lining adheres so well and a further protection is afforded so easily that it is preferable to use it. If melted sulphur is plastered onto a concrete surface, which has not been previously specially treated, it soon cracks off. The sulphur lining is itself somewhat porous on account of the contraction that takes place when sulphur solidifies. Furthermore, sulphur is not absolutely insoluble in water and acids, and the continual presence of traces of sulphur in the electrolytes is not desirable, so a coat of suitable paint or varnish or paraffin is applied to the sulphur surface. In case the sulphur lining is omitted the paint, etc., is applied directly to the sides of the tank. Melted paraffin is excellent for this purpose if the solutions to be used in the tank are not heated, and only a small amount of paraffin is required. Before using the tank it should have a lining of boards to protect it from any injury that might be received from pieces of metal dropping or swinging in the tank. This tank is so solid that the great brittleness of sulphur which causes it to break when there is the slightest "give" is no objection to its use. To make a good exterior, non-absorbent finish on the outside, it may be treated in a similar manner or quickly dipped in melted sulphur, when a smooth, hard layer of sulphur is produced on the surface. Such a tank is non-absorbent and practically proof against dilute acids, even hydrofluoric acid. It is stated that porous earthenware vessels may be treated in a similar manner, or brick may be made non-absorbent and acid-proof. For tank construction, the brick may first be saturated with sulphur in a pot and then laid up with a plastic mortar of kaolin, instead of with melted sulphur. (918,649, April 20.)

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Combined Arc and Resistance Furnace.—For the reduction of elements which at the temperature of reduction are subject to losses by volatilization (for example, silicon), it is important to remove the reduced products as soon as formed from the zone of maximum heat. For this purpose Mr. Frank J. Tone, of the Carborundum Company, employs a combined arc and resistance furnace. The fundamental idea is to cause the products to descend (by gravity) from the reaction zone of the arc along an electrically heated resistance conductor. One terminal of the furnace is formed by an electrode suspended far above. In a hole in the bottom of the furnace is placed a carbon base-block which constitutes the other terminal. On the central part of this base-block rests a resistance conductor, in form of a column of carbon or other conductive refractory material, which is so formed as to give resistance to the passage of the current and therefore heat the product of the furnace as it descends from the zone of reaction. The upper end of this resistance conductor constitutes the lower electrode of the arc, which is maintained between the lower end of the upper electrode and the top of the resistance conductor. The charge fills the furnace and surrounds the upper electrode, so that the arc is completely enclosed in the mass of charge. As reduction progresses, the reduced products descend along the heated resistance conductor into the receiving space in the lower end of the cavity from which they may be tapped. To express it briefly, the lower electrode is intended to serve both as resistor and as electrode for the arc above. (921,183, May 11.)

Titanium Oxide.—Magnetic separation, together with partial smelting, is employed in an interesting manner in a process of F. A. J. FitzGerald and P. McN. Bennie for the production of pure titanium oxide from ilmenite ore, which has the approximate formula $FeO.TiO_2$, but is often accompanied by considerable quantities of magnetite as gangue. The ore is crushed, and after a preliminary magnetic separation (in order to remove any magnetite that may accompany the ilmenite) it is mixed with a reducing agent, preferably coke (so that the mixture contains from 7.3 to 10.6 per cent of carbon) and is heated to a temperature sufficiently high to reduce the iron, but not the titanium, to the metallic state. The reduction process, when 7.3 per cent carbon is used, follows the equation

$$FeO.TiO_2 + C = Fe + TiO_2 + CO,$$

while with 10.6 per cent carbon the following reaction may be expected:

$$2FeO.TiO_2 + 3C = 2Fe + Ti_2O_3 + 3CO.$$

As all that is necessary is to effect reduction of the iron to the metallic state, the percentage of carbon may be such that both reactions occur. The approximate temperature of the reaction is 1800 deg. C. This temperature will give a sintered mass which may more easily be crushed than the compact, fused mass resulting from a higher temperature. By crushing the metallic iron particles are mechanically freed from the titanium oxide. By means of magnetic separation the iron is then separated from the titanium oxide. The non-magnetic portion is then treated with acid in order to remove as completely as possible the small amount of iron not removed by magnetic separation. Digestion with 10 per cent sulphuric acid until no further action takes place is an effective acid treatment. The powder remaining after acid treatment is washed and dried and will be practically pure titanium oxide. (921,686, May 18.)

Tin Plating.—The following electrolyte for tin plating is patented by Mr. Jay C. Beneker, the patent being assigned to the Meaker Company, of Chicago. 25 parts sodium hydrate, 15 parts sodium thiosulphate, 10 parts crystallized stannous chloride, 200 parts water. Preferably a solution is made of each, mixing the solution of stannous chloride and sodium hydrate, then adding the sodium thio sulphate. The solution thus formed may be used either hot or cold as an electrolytic bath for plating, but preferably hot. The reaction that takes place is probably as follows: The tin chloride combined with the sodium hydrate forming sodium stannite,

$$2NaOH + SnCl_2 = NaCl + Na_2SnO_2 + H_2O.$$

The thio sulphate then transforms this stannite to a sulfosalt changing all or most of the stannous to the stannic form. Probably the chief ingredient in the final solution is sodium thio-stannate Na_2SnS. This compound in a high degree can be electrolyzed without the tin separating in a spongy or "tree" form. For tin coatings thio sulphate is employed for the purpose of transforming alkaline or alkaline earth stannites to alkaline or alkaline earth thio stannates, thus changing the valency from the "ous" to the "ic" form, in which form only are the thio salts of tin known. These sulfo compounds are also formed even when the valency is not changed, as in the case where mercuric or stannic salts are made the starting point. With this solution, using any convenient anode but preferably one containing the metal to be plated out, excellent deposits of tin or any allied metal can be plated out without the formation of a spongy or tree-like deposit, even when using high-current densities. (921,943, May 18.)

Electrolytic Production of Chlorates and Hypochlorites.—In the production of chlorates and hypochlorites from chlorides by electrolysis, it is important to prevent the chlorate or hypochlorite from being again reduced at the cathode. Mr. A. G. Betts prevents this by employing a cathode of magnesium. In this case there is little or no reduction at the cathode, which is explained by the great superficial oxidizability of the magnesium, so that the surface is always covered with a thin porous layer of non-conductive megnesia, probably in hydrated form, which serves as a thin ever-present diaphragm, preventing the contact of more than small portions of the electrolyte and contained reducible compound with the actual cathode surface. (The hydrogen set free after leaving the cathode has practically no reducing power.) By this method it is not necessary to have any salts of magnesium, calcium, etc., in the solution, so that none of the current is used for the decomposition of such salts. The method is especially useful in the production of hypochlorites for bleaching purposes, having the advantage over the well-known process using an addition of chlorates for the purpose of securing high current efficiency, of producing a colorless solution. In trying to make hypochlorites with a cathode of aluminum, which is almost as oxidizable as magnesium, Mr. Betts found that the caustic generated at the cathode dissolved the aluminium rapidly, and the loss of aluminium was found to be very great in contrast to magnesium, of which the hydroxide is not soluble in caustic solutions. (918,659, April 20.)

Nickel-Steel from Nickel Ore.—A. G. Betts has invented an interesting electrolytic process for producing nickel-steel from iron pyrites, containing nickel, copper, etc. The ore is transformed by roasting into a crude nickel-iron alloy, which is used as anodes in a refining bath, the nickel and iron being deposited together on the cathode, while the copper, etc., remains in the anode slime. Details of the process are given elsewhere in this issue, in the department "Recent Metallurgical Patent." (923,005, May 25.)

Carbon Cell.—After the carbon cell—that old favorite problem of electrochemists—has had a comparative rest for some ten years, Mr. E. W. Junger, of nickel iron storage battery fame, has now entered this field. His gas cell for this purpose was described in our Vol. VI, p. 250. In a recent patent he believes he can solve the problem in a more direct way. By using a concentrated sulphuric acid solution, as electrolyte, with amorphous carbon as anode and an unattackable graphite cathode which absorbs oxygen from the atmosphere, he claims he has an oxygen-lift cell in which the electrolyte and the graphite cathode remain unaltered; the whole reaction consists in transportation of the atmospheric oxygen from the cathode to the anode and oxidation of the anodic carbon. To

facilitate this he adds to the sulphuric acid solution, either gases of nitrogen oxides, like NO, N_2O_3, NO_2, or chlorine compounds of such gases, or sulphates of manganese, chromium, etc. Two types of cell are described; in one of these a diaphragm is used. The electrolyte is artificially heated. "The working tension of each element at normal charge will, in round numbers, be half a volt. The theoretical tension of the combination carbon-oxygen being about one volt, about 50 per cent of the energy of the combustion is thus utilized, i. e., about ten times as much as in a modern steam engine." We comment on this cell in an editorial note. (919,022, April 20.)

SYNOPSIS OF PERIODICAL LITERATURE.

Ozone for Water Purification and Sewerage Treatment.—In the London *Electrician* of May 21 an ozone plant for water purification in Nice is described. The power required for the pump is 26 kw, that for the ozonizer is 78 kw. The Otto system is used. The voltage used in the ozonizer is 20,000. In the same article it is suggested that the ozone process could also be applied to the treatment of sewerage effluent. Air is drawn through the ozonizers and is then carried to a mixing chamber which affords thorough contact between the ozone and the water, and the mixture is then carried through a sterilizing gallery, by which means the liquid is thoroughly saturated. "Taking a system in which it is required to treat 25,000 gal. of sewerage effluent per hour, or 600,000 gal. per day, the solids in suspension in the water to be treated may be allowed for at the rate of 3 grains per gallon, or 42.8 grams per 220 gal. The total weight would be 230 lb. per 24 hours. As the matter in suspension would be very fine, it would be necessary to employ a coagulant, such as sulphate of alumina, and to pass the mixture through a precipitation tank, but a roughing tank would usually be sufficient to treat this amount of suspended matter. For pumping purposes a centrifugal pump is employed to raise the effluent to a height of 10 m at the rate of 31.1 cu. m per second, and taking the efficiency of the pump at 0.6 the necessary power is 6.8 hp. For the production of ozone, allowing 1 gram per 100 gal., 246.4 grams would be necessary for 112 cu. m, and the power would be 7392 watts. Taking into account the efficiency of the alternator this would involve 14.4 hp. The exciter absorbs 0.57 hp, and the total power for the whole plant would be 22 hp. The plant required to deal with this output would be a centrifugal pump, a 15-kw single-phase alternator of 500 cycles, 220 volts, with an exciter, a distributing board complete with instruments for control and measurement, a single-phase transformer converting from 220 to 15,000 volts at 500 cycles requiring about 15 kv-amp, a seven-element battery ozonizer for 246.6 grams of ozone, requiring 1056 watts per element, and an emulser composed of 100 aspirators mounted in a cylindrical iron box with an enameled interior, each having an output of 1.12 cu. m per hour under a pressure of 13 ft."

"For an output of double the capacity the pump power required would be 14 hp, the energy consumption in ozonization 15 kw and the total power for the alternator 44 hp." The author thinks that the scheme is not visionary and gives the following list of other ozone apparatus installed for the purification of drinking water: At Dinard and Cosne 528,000 gal. are treated per 24 hours at each place; at Chartres 1,210,000 gal. per 24 hours; at Armentieres 660,000; at Avranches 506,000; in a second installation for Dinard 506,000, etc., while at the following towns installations have been erected or are in course of construction to deal with 6,000,000 gal. per day: Villefranche, Beaulieu, Saint Jean, Eze, La Turbie, Gabbe-Roquebrune, Menton, Monaco, Monte Carlo and other towns. Where iron appears very largely in solution it is necessary to precipitate this before using the ozone apparatus, but "it may be roughly taken that for the treatment of 1,000,000 gal. per day of sewerage effluent the cost of the whole of the plant necessary would be between $15,000 and $20,000, while the working expenses for such a system can be gauged from the figures of power required, given above."

Iron and Steel Institute Meeting.—An account of the recent meeting of the Iron and Steel Institute in London is given in London *Engineering* of May 14 and 21. One of the subjects under discussion was the corrosion of iron and steel. Two papers were presented on the theory of corrosion of iron, one by Dr. Wm. H. Walker, the other by Dr. A. S. Cushman, both dealing especially with the electrolytic theory and the possibilities of inhibiting corrosion. A paper by Mr. J. Cruickshank Smith discussed physical tests of protective coatings for iron and steel. As to tests applicable to the paint itself, he discussed the following: The pigment and vehicle should be properly proportioned in order to ensure efficient application and the minimum of free oil space in the dry film; the size of the pigmentary particles should be small and uniform; the pigment and the vehicle should possess the minimum tendency to separate from each other. An accelerative test is possible by exposing the paints to severe conditions for a short space of time, and by examining the films so produced in order to see whether they are free from the defects which one would expect to find in them after so long exposure under milder conditions. Of tests applicable to the film, the following were dealt with: Determination of the thickness and uniformity of the film; strength of film as determined by breaking machine; elasticity of film; permeability of films by vapors and gases; hardness of surface of films.

A very long paper by Prof. E. Heyn and O. Bauer dealt with the influence of the treatment on the solubility of steel in sulphuric acid; a paper by Mr. W. H. Hatfield with the chemical physics involved in the decarbonization of iron-carbon alloys; a paper by Dr. M. Eckenberg with fuel from peat; a paper by Professor McWilliams and Mr. E. J. Barnes on a heat-treatment study of Bessemer steel.

Mr. W. Rodenhauser, of Sarbrücken, Germany, of Roechling-Rodenhauser furnace fame, contributed a paper in which he first summed up what he considered to be the disadvantages of the different arc furnaces, and then described the simple induction and the combination furnace. This paper led to quite a long discussion on the electrometallurgy of steel. Mr. A. Windsor, as a practical steel man, thought the cost of electric steel making would have to be cheapened. The high quality of electric steel was, in his opinion, not so much due to low percentages of phosphorus and sulphur, but to the absence of gases—principally nitrogen and oxygen—in the steel. Mr. O. Frick, himself an inventor of an electric furnace of the induction type, criticised many statements of Mr. Rodenhauser's paper and even defended the different arc furnaces against Rodenhauser's criticisms. He made some interesting remarks on his own furnace, stating that there is now a Frick furnace at work at the Krupp Works at Essen. This is a 10-ton furnace working at an $8\frac{1}{2}$-ton charge, and its results have been so satisfactory that the Krupp firm has taken over his German patent. He stated that the slag could be worked very conveniently in the Frick furnace. Mr. Hiorth, the inventor of another induction furnace, also spoke. Mr. Moorwood urged that the electric furnace should now pass out of the hands of the electricians and be handed over to the steel makers. Mr. A. Cooper thought that the electric-steel furnace could not form a serious competitor until, at all events, it could start with blast-furnace or mixer metal, instead of starting with steel.

The Bessemer gold medal was presented to Mr. A. Pourcel, of Paris, as a recognition of his eminence in the steel industry of France. Mr. Pourcel entered the Terrenoire Works in 1860. He established Bessemer works in 1867; open-hearth steel works followed. He was the first to manufacture ferromanganese and silicospiegel in the blast furnace. He developed the manufacture of solid-steel castings. He built steel works at Bilbao, and an open-hearth plant at the Clarence Iron Works. Sir Hugh Bell will remain president of the Institute for next year.

Combined Roasting and Smelting Processes for Copper Ores and Fires.

Two novel processes, especially applicable to the treatment of fines, have recently attracted considerable attention. One is the **Fink process**, which has been tried at the Boston Consolidated Company's plant at Garfield, Utah. The other is the **Catton process**, which has been tried at West Seattle, Wash.

Both processes are very similar in principle. In both the furnace consists of two halves, in one of which roasting is carried out, while smelting proceeds in the other, the heat of the gases of reaction in the smelting chamber being directly utilized in the roasting chamber. After roasting is completed, the smelting proceeds in the same chamber, while fresh ore is roasted in the other chamber, so that the function of the two halves of the furnace is now reversed. In this way a high economy of fuel is obtained in both processes. Moreover, both the Fink and Catton processes are designed for use of crude oil as fuel. Finally, in each process fines and concentrates can be roasted without preliminary treatment.

FIG. 1.—FINK FURNACE.

Since these processes, if they prove as successful on a large scale as they have proven in the experimental runs, would solve the problem of rendering profitable many propositions at present unprofitable, a brief description of both processes will be interesting.

* * *

In the tests of the **Fink process** at Garfield, Utah, concentrates containing 20 per cent of copper were reduced to blistered copper in a short time. Fig. 1, which is reproduced from the Salt Lake *Mining Review*, shows the two revolving cylinders side by side which make up the Fink smelter. The two ends of the cylinders, which join together at the center, are connected to a central flue. The other two ends of the cylinders are connected to chimneys. In the Garfield plant, with an estimated daily capacity of 100 tons, these cylinders have a length of 9 ft. and a diameter of 9 ft. outside and 7 ft. inside, but tapering at the ends. Near the center of the cylinders there are three tapholes for the removal of slag, matte and metal.

It was intended to use oil as fuel, but since a sufficient supply was not available at the time of the tests, powdered coal was used. The Fink furnace may be compared with a revolving roasting furnace, but differs from the latter in so far as there is no firebox, the fuel being burned in the cylinder itself. The fuel is introduced into the cylinder at the center, where tuyeres are also provided to blow air into the cylinder for bessemerizing.

Both cylinders are in operation at the same time. Let us assume that the roasting operation in cylinder No. 1 has just been completed and that the smelting or bessemerizing in cylinder No. 2 has also been completed. The matte or blister copper is now removed from cylinder 2, but the slag is left in, and a new supply of ore is introduced into 2. Smelting now begins in cylinder 1 and the gases from this cylinder are passed consecutively through the middle flue into cylinder 2 with the fresh ore, which is now being roasted, then into a dust chamber and then to the stack. No fuel is required for the roasting in cylinder 2, the sulphur from the ore and the hot gases from cylinder 1 being sufficient.

At the proper moment the matte or metal is removed from cylinder 1, new fines are introduced into 1 to be roasted, while the roasted ore of cylinder 2 is now smelted, and so on. For bessemerizing, of course, the tuyeres in the center are turned on. The ore, while remaining in the same compartment, is therefore successively roasted, smelted and bessemerized, and no fuel is needed for the roasting operation.

Besides this economy of fuel and the smelting of fines and concentrates without preliminary treatment, other advantages claimed for this process are that the fine ore is not subjected to the blast, but run into the converter slag from the proceeding bessermerizing operation, thus preventing a loss of fines; that the ore is completely converted into metal without preliminary treatment in one compartment, and that the furnace may be used either continuously or intermittently as desired.

According to the newspaper reports the Garfield tests of the Fink process were quite successful.

* * *

Similar satisfactory results are reported concerning the working of the Catton furnace, which is shown diagramatically in Figs. 2 and 3.

The furnace, which is built of brick, is 35 ft. overall long, 10 ft. wide and about 8 ft. above ground. The flues *A'* and *A* are continued out to the neck of the stack. A butterfly damper is placed at *B*, while *C* is a steam pipe in the funnel *D*. Steam is turned on at 90-lb. pressure and syphons air with it through the funnel *D* and travels through the flue *A* and on up through the red-hot checker-work chamber and ports *E*, meeting the oil, which is put in under 90-lb. pressure, at *F*.

Combustion immediately takes place and the flame is thrown against the foot wall at *G* and plunges down in the hearth *H*,

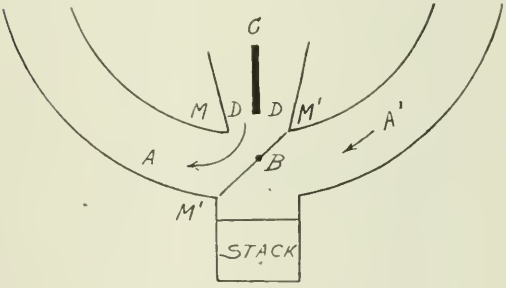


FIG. 2.—CATTON FURNACE.

along which it travels over the well and up the opposite hearth to *H'*, where the first charge of ore has been put through the hopper *K*; the hot gases continue on through the port *E'*, the checker-work chamber (keeping it at the required heat) and flue *A'* to the stack.

When the ore at *H'* has been sufficiently roasted (the time being from 15 to 45 minutes according to the nature of the ore) the oil is turned off at *F* and is turned on on the other side, so as to direct the flame now onto the other hearth *H'*. The butterfly damper *B* is turned from *M'* to *M*, making the steam and air pass through the flue *A'* instead of *A*, as formerly, a charge of fresh ore is made at *H*. The oil flame is now turned onto the roasted ore on *H'*, while the hot gases pass over and roast the new charge on *H*. When the first charge at *H'* has melted it runs down to the well, since the two hearths are built sloping from their extreme ends toward the well in the center. The slag is tapped from the well at *L* and the matte at *N*. The

whole operation, which takes about one hour, is extremely simple and the heat is under perfect control. The operation begins now all over again; a new charge is being fed into the furnace alternately at either end, and the smelting process is continuous.

The fuel used is crude oil, air and steam. In the tests made matte has been produced assaying from 15 to 42 per cent copper, being concentration of from 6 to 20 to 1, according to the character of the ore, without any preliminary roasting or crushing.

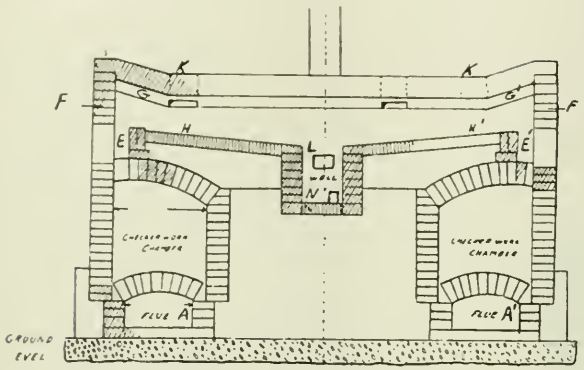


FIG. 3.—CATTON FURNACE.

The Catton furnace is built entirely of brick, common brick wall, firebrick lining and magnesite or chrome brick smelting hearths. It is the use of the oxidizing flame in desulphurizing the ore at one end while the reducing flame is smelting at the other end, which results in the high economy of the process.

At the recent public demonstration of West Seattle it is stated that nothing but mine run of crude ore had been fed into the furnace. With crude ore a concentration of 12 into 1 was made on a charge, carrying 10 per cent sulphur, 5½ into 1 on a 20 per cent sulphur charge, and 4 into 1 on a 28 per cent sulphur charge.

The Catton process of smelting is owned by the State Mining & Smelting Company, of Seattle, Wash., from whom the patent rights for California, Oregon, Nevada, Arizona and New Mexico have been purchased by Col. C. Christopher Seattle, who has retained Mr. Walter S. Keith as consulting engineer. Commercial smelters will be in operation in California and Washington by September of this year.

According to a statement of Mr. Keith the following points have been proven in tests of the Catton furnace during the past six months:

"The cost of fuel per ton of ore smelted will not exceed 35 per cent of blast-furnace cost. The separation made is at least equal to that made in any blast or reverberatory furnace. It can without danger of freezing, maintain a charge resulting in a 50 per cent silica slag. The concentration obtained is equal to that obtained in blast-furnace practice. No flue dust is made during the smelting operation. The loss by volatilization is practically nil."

Mr. Keith estimates that the cost of smelting, in a furnace of 50 tons capacity properly equipped for handling the ores, would not exceed $2 per ton. This, of course, refers to a fluxed ore charge with furnace located on seaboard or main line of railway.

As compared with the Fink process, the Catton process is stated not to require any preliminary crushing whatever, as the ordinary mine run of crude ore can be directly charged into the furnace. With respect to construction, the fact that the Catton furnace is entirely built of brick is considered to represent a great advantage, especially in localities remote from easy shipping facilities. For the first cost it is of importance that no machinery for preliminary crushing is required.

Creosote and Zinc Chloride for Wood Preservation.

More than 56,000,000 gal. of creosote and nearly 19,000,000 lb. of zinc chloride were used in preserving timber in the United States last year. Small quantities of crude oil, corrosive sublimate and other chemicals were also used.

These figures are based upon reports to the United States Forest Service of 44 firms which operated 64 timber-treating plants. Assuming that on an average 1 gal. of creosote, or one-third of a pound of zinc chloride, will protect a cubic foot of timber from decay, more than 100,000,000 cu. ft. of cross-ties, piling, poles, mine and other timbers were given a treatment that will greatly increase their life and usefulness.

In 1908 almost seven-tenths—to be exact, 69 per cent—of the creosote used by the treating plants was imported, and but 31 per cent was obtained from domestic sources. Nearly three-fourths of the imported creosote comes from England and Germany, some is obtained in Nova Scotia and some in Scotland and Holland. The domestic creosote used by the treating plants was obtained chiefly in New York, Philadelphia and other large cities.

Creosote is distilled from coal-tar. Not more than 20 per cent of the coke used in the United States is made in by-product ovens.

Were all the tar produced which the coal annually coked in the United States is capable of yielding, it would distill as much creosote as is now used by the wood preservers. Unfortunately, American operators do not even get the fullest use of the limited quantity of coal-tar made in this country for it does not pay the operators to distill coal-tar for creosote alone; so, unless they can find a market for the associated products, it is not separated. Germany has gone far ahead of the United States in the development of coal-tar products, and her exports of them to this country are steadily increasing.

The zinc chloride used in wood preservation is all obtained from domestic sources, according to the reports. Most of it is produced by a few large chemical companies.

Cross-ties are particularly liable to decay, since they are used under conditions which are favorable to the growth of the wood-destroying fungi. Consequently, the railroads have always taken a leading part in timber preservation in the United States. Twelve of the 44 firms which are operating timber-treating plants are railroad companies. The railroads also have many ties treated by commercial timber-treating plants.

In 1907, according to Forest Products Bulletin No. 8 of the Bureau of the Census, the steam railroads of the United States used 19,192,000 treated ties, of which 11,217,000 ties were treated at their own plants and 7,975,000 ties were treated at other plants.

The electric roads used 664,000 treated ties in the same year, nearly two-thirds of which were purchased already treated. The majority of the treated ties used by the steam railroads was preserved with zinc chloride, while with the electric roads more ties were treated with creosote than with any other one preservative.

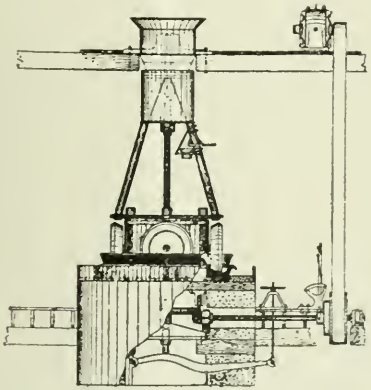
Many telephone and telegraph poles are creosoted, and there is a growing use of treated timber by the most progressive mine operators. In many harbors, the only practical method of protecting piles from the destructive teredo is to creosote them heavily. One of the most recent uses of creosoted wood on an extensive scale is for rectangular wooden-block pavement. New York, Boston, Baltimore, Indianapolis, Chicago and other large cities are using large quantities. Creosoted wooden blocks have been laid in front of the new terminal station building in Washington.

Automatic Quartz Mill for Gold Ores.

The Vaughn automatic quartz mill, built by the Vaughn Automatic Quartz Mill Machinery Company, Portland, Ore., is intended for the free milling, concentrating and cyaniding of gold ores. It is similar to the Chilian mill in fine grinding and produces high results in amalgamation in the mortar, without the use of amalgamation plates.

The shape of the rolls, which work in corresponding grooves in the dies in the mortar, make the operation self-adjusting, so that uniform results are obtained from the time that the roll shells are put on new until they are worn out. To replace the roll-shells requires but a few minutes.

Where the ore can be ground to a very fine pulp, in connection with a large amount of mercury, the greatest portion of the gold is recovered at the least expense. In milling ore which contains free gold mixed with lead, antimony sulphides or arsenical pyrite, and most of the base elements in combination, it is claimed by the manufacturers that the Vaughn mill will save from 15 to 20 per cent more of the values than other systems now in use, while requiring only one-third the power. The principal reason for this is that the crushing is continuous, while



VAUGHN MILL.

with stamps, for instance, but a small percentage of the time is actually consumed in crushing the ore, a great amount of the time being occupied in the lifting and the falling of the stamp. The application of weight, with a rolling pull in a metal surface, with a constant feed ahead of the rolls, is what gives the mill its great capacity, with a small amount of power.

The V-shaped die makes the ore stop at the proper place at all times, and gives positive action for crushing. With this method the ore is uniformly distributed and absolutely under the control of the batteryman.

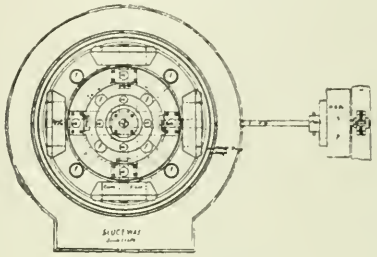
The Vaughn automatic quartz mill is manufactured in two sizes. The No. 3 mill has a capacity of 25 tons in 12 hours when working on the hardest kind of ore. The power required under the heaviest service is 20 hp; the water required is 15 bbl. to 25 bbl. for free milling and concentrating under heavy service.

The No. 4 mill has a capacity of 50 tons in 12 hours, and requires but little more power than the No. 3 mill, with some more water in proportion to the moisture in the ore.

These mills are interchangeable for wet or dry crushing. The installation of the battery for dry work requires an enclosure of lumber or metal. At the outlet of the pulverized ore an exhaust fan is used to carry the pulp to the cyanide tanks, where it is sprayed with the cyanide solution as it goes into the tanks.

The deterioration of the roll-shells and the dies is usually about 2 lb. of metal to one ton of the hardest rock, in grinding the ore to 100 mesh to the linear inch. In dry crushing the mill can attain 40 r.p.m. to 50 r.p.m., while for wet work 20 to 25 revolutions is about the maximum speed. When working ore in the dry way all the free gold that occurs in the ore is left in the battery, where it can be cleaned up whenever advisable.

In order to make this clean-up a section of the enclosure is removed and water and mercury is applied in the mortar and



SECTION OF VAUGHN MILL.

the mill put in motion. In a few minutes the gold is all converted into amalgam, which is then ready to be cleaned out.

A building 32 ft. x 32 ft. square is sufficiently large to contain four of the No. 4 batteries for dry work.

Some of the particular advantages of the Vaughn mill, stated by the manufacturers, are that it is possible to take assays at any time while the mill is in operation; that it greatly reduces the usual heavy expense for the mill building (the Vaughn mill being self-contained), and that only half as many attendants are required as with stamp mills.

A New Viscosimeter.

The new Stormer viscosimeter, designed by Chief Chemist Stormer, of the J. I. Case Threshing Machine Company, and made by the Bausch & Lomb Optical Company, of Rochester,

VISCOSIMETER.

N. Y., is an instrument distinctly new in design. Since it comes from a practical chemist who has found it superior to other forms in making a large number of determinations daily, it may be expected to appeal to other practical men.

The principle employed is that of a paddle wheel driven by a constant force. This paddle wheel is equipped with indicator so that the number of revolutions made in a liquid within a

given time may be recorded, or the time required to register a given number of revolutions may be used as the basis for determining the comparative viscosities of oils, varnishes, etc. The principal points of advantage which have been gained are:

Only 50 cc sample is required for the determination of viscosity and the temperature of this small quantity may be easily controlled.

Only a few seconds are required to make a test and the temperature variation during the test is negligible.

The reading may be repeated and checked with great ease, it being only necessary to wind the indicator back to zero in order to be ready to repeat the determinations.

The force exerted is constant throughout the experiment.

Different oils may be run successively without the loss of time, since a clean cup and a cleaning of the small paddle wheels puts the instrument in order for a new test.

With this viscosimeter there is not such a great variation in viscosities as is shown in some of the outflowing types of instrument.

Only the stop watch need be kept in mind, since the number of revolutions is automatically recorded and a convenient brake stops the revolution of the wheel instantly at the desired moment.

Further information, direction for use and prices may be obtained of the makers.

"Permissible" Explosives in Mines.

As a part of the investigation of mine explosions authorized by Congress in May, 1908, it was decided by the Secretary of the Interior that a careful examination should be made of the various explosives used in mining operations, with a view to determining the extent to which the use of such explosives might be responsible for the occurrence of these disasters.

The preliminary investigation showed the necessity of subjecting to rigid tests all explosives intended for use in mines where either gas or dry inflammable dust is present in quantity or under conditions which are indicative of danger.

With this in view, a letter was sent by the director of the United States Geological Survey on Jan. 9, 1909, to the manufacturers of explosives in the United States, setting forth the conditions under which these explosives would be examined and the nature of the tests to which they would be subjected. The first report on these tests has just been issued by the Geological Survey.

The test requirements for explosives were outlined as follows:

The tests are made by the engineers of the United States Explosive Testing Station at Pittsburgh, Pa., in gas and dust gallery No. 1. The charge of explosive to be fired in tests 1, 2 and 3 shall be equal in disruptive power to ½ lb. (227 grams) of 40 per cent nitro-glycerin dynamite in its original wrapper, of the following formula: Nitro-glycerin 40, nitrate of sodium 44, wood pulp 15, calcium carbonate 1.

Each charge shall be fired with an electric fuse of sufficient power to completely detonate or explode the charge, as recommended by the manufacturer. The explosive must be in such condition that the chemical and physical tests do not show any unfavorable results. The explosives in which the charge used is less than 150 grams (0.22 lb.) will be weighed in tinfoil without the original wrapper.

The dust used in tests 2, 3 and 4 will be of the same degree of fineness and taken from one mine with a view to obtaining a dust of uniform purity and inflammability.

Test 1.—Ten shots with the charge as described above, in its original wrapper, shall be fired, each with 1 lb. of clay tamping, at a gallery temperature of 77° Fahr., into a mixture of gas and air containing 8 per cent of methane and ethane. An explosive will pass this test if all 10 shots fail to ignite the mixture.

Test 2.—Ten shots with charge as previously noted, in its original wrapper, shall be fired, each with 1 lb. of clay tamping at a gallery temperature of 77° Fahr., into a mixture of gas and air containing 4 per cent of methane and ethane and 20 lb. of bituminous coal dust, 18 lb. of which is to be placed on shelves laterally arranged along the first 20 ft. of the gallery, and 2 lb. to be placed near the inlet of the mixing system in such a manner that all or part of it will be suspended in the first division of the gallery. An exposive will pass this test if all 10 shots fail to ignite the mixture.

Test 3.—Ten shots with charge as previously noted, in its original wrapper, shall be fired, each with 1 lb. of clay tamping at a gallery temperature of 77° Fahr., into 40 lb. of bituminous coal dust, 20 lb. of which is to be distributed uniformly on a horse placed in front of the cannon and 20 lb. placed on side shelves in sections 4, 5 and 6. An explosive will pass this test if all 10 shots fail to ignite the mixture.

Test 4.—A limit charge will be determined within 25 grams by firing charges, in their original wrappers, at a gallery temperature of 77° Fahr., into a mixture of gas and air containing 4 per cent of methane and ethane and 20 lb. of bituminous coal dust, to be arranged in the same manner as in test 2. This limit charge is to be repeated five times under the same conditions before being established.

At least 2 lb. of clay tamping are used with slow-burning explosives.

In reply to the circular letter, applications were received from 12 manufacturers for the testing of 29 explosives. Of these the 17 given in the following list have passed all the test requirements set forth, and are termed "permissible explosives."

Subject to the conditions named below, a permissible explosive is defined as an explosive which has passed gas and dust-gallery tests Nos. 1, 2 and 3 as described above, and of which in test No. 4 1½ lb. (680 grams) of the explosive has been fired into the mixture there described without causing an ignition.

PERMISSIBLE EXPLOSIVES TESTED PRIOR TO MAY 15, 1909.

Brand.	Manufacturer.
Etna coal powder A	Etna Powder Co., Chicago, Ill.
Etna coal powder B	Etna Powder Co., Chicago, Ill.
Carbonite No. 1	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.
Carbonite No. 2	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.
Carbonite No. 3	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.
Carbonite No. 1 L. F	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.
Carbonite No. 2 L. F	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.
Coal special No. 1	Keystone Powder Co., Emporium, Pa.
Coal special No. 2	Keystone Powder Co., Emporium, Pa.
Coalite No. 1	Potts Powder Co., New York City.
Coalite No. 2 D	Potts Powder Co., New York City.
Collier dynamite No. 2	Sinnamahoning Powder Co., Emporium, Pa.
Collier dynamite No. 4	Sinnamahoning Powder Co., Emporium, Pa.
Collier dynamite No. 5	Sinnamahoning Powder Co., Emporium, Pa.
Masurite M. L. F	Masurite Explosive Co., Sharon, Pa.
Meteor dynamite	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.
Monobel	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.

Provided:

1. That the explosive is in all respects similar to the sample submitted by the manufacturer for test.

2. That double-strength detonators are used of not less strength than 1-gram charge consisting by weight of 90 parts of mercury fulminate and 10 parts of potassium chlorate (or its equivalent), except for the explosive "Masurite M. L. F.," for which the detonator shall be of not less strength than 1½ grams charge.

3. That the explosive, if in a frozen condition, shall be thoroughly thawed in a safe and suitable manner before use.

4. That the amount used in practice does not exceed 1½ lb. (680 grams) properly tamped.

The above partial list includes the permissible explosives that have passed these tests prior to May 15, 1909.

It may be wise to point out in this connection certain differences between the permissible explosives as a class and the black powders now so generally used in coal mining, as follows:

(a) With equal quantities of each, the flame of the black

powder is more than three times as long and has a duration 3000 to more than 4000 times that of one of the permissible explosives, also the rate of explosion is slower.

(b) The permissible explosives are $1^1/_4$ to $1^3/_4$ times as strong and are said, if properly used, to do twice the work of black powder in bringing down coal; hence only half the quantity need be used.

(c) With 1 lb. of a permissible explosive, or 2 lb. of black powder, the quantity of noxious gases given off from a shot averages approximately the same, the quantity from the black powder being less than from some of the permissible explosives and slightly greater than from others. The time elapsing after firing before the miner returns to the working face or fires another shot should not be less for permissible explosives than for black powder.

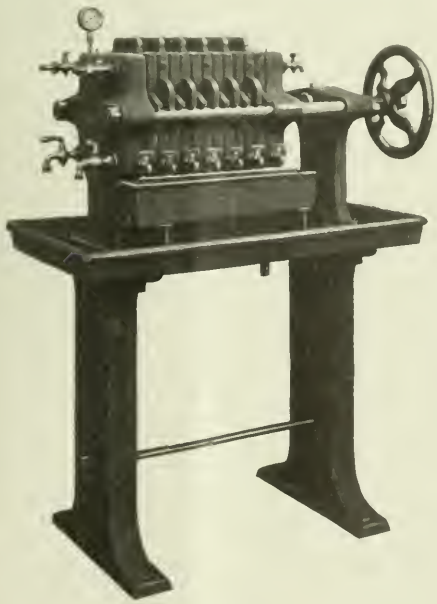
The use of permissible explosives should be considered as supplemental to and not as a substitute for other safety precautions in mines where gas or inflammable coal dust is present under conditions indicative of danger. As stated above, they should be used with strong detonators, and the charge used in practice should not exceed $1^1/_2$ lb., and in many cases need not exceed 1 lb.

Inasmuch as no explosive manufactured for use in mining is flameless, and as no such explosive is entirely safe under all the variable mining conditions, the use of the terms "flameless" and "safety" as applied to explosives is likely to be misunderstood, may endanger human life, and should be discouraged.

The report is signed by Joseph A. Holmes, expert in charge technologic branch, and approved by George Otis Smith, as director.

Filter Press.

In our May issue we described at length the equipment of the Chemical Engineering Department of the University of Wisconsin. The adjoining illustration shows a filter press built especially for this department by Messrs. D. R. Sperry & Company, of Batavia, Ill.



FILTER PRESS.

This filter press is made of cast iron; each plate surface has an area of $^1/_2$ sq. ft., and each frame space is equal to 1.24 cu. ft. It can be used for experimental work in various ways. Volatile or oxidizable solutions, which would be affected by contact with air, may be filtered and discharged through an internal channel, away from contact with the air. On the other hand, with ordinary solutions, the filtrate is discharged into an open trough so that the completeness of the filtration may be seen at once. It is also arranged for "absolute washing" or extraction.

As mentioned by Prof. J. C. Dickerman in an article in the *Wisconsin Engineer*, this press is an exact model of a full-sized press of the most modern type, so that data concerning the best pressure, most effective filtering medium, bulk of the compact solid residue, volume of wash liquor or extraction solution necessary, physical and chemical characteristics of the residue or cake, and many other items can be obtained and used with confidence in the design of a plant. The press is available for filtering any substance which will not seriously corrode the iron, such as causticised soda ash, sugar, various salts, etc.

As a means of forcing the turbid solutions into the press a montejus, or pressure tank, has been installed. Either steam or compressed air may be used to exert the necessary pressure. The piping is so arranged that the solution may be heated with steam before filtering. The montejus also serves as a convenient dissolver where heating and agitation under pressure are desirable, and the dilution from the condensed steam can be neglected or allowed for.

Sulphur in Illuminating Gas.

Gas regulations in force in Massachusetts and elsewhere, calling for gas containing not over 20 grains of sulphur per 100 cu. ft., are a source of great trouble for the gas manufacturer. He must either buy at a premium low sulphur coal, in which case he has to compete with the iron and steel industry, or he must employ some expensive method of gas purification.

These gas regulations are based on the idea that sulphur in gas is a nuisance and unsanitary. This idea has been repeatedly fought by the gas people; from a recent report by Mr. ARTHUR D. LITTLE, chemical expert and engineer, of Boston, Mass., we quote the following results of experiments carried out at Malden, Mass., on the influence of sulphur in gas or air in rooms:

"There is no reason to believe that, under the conditions of their occurrence, sulphur acids formed in burning luminous gas have any deleterious action on wood.

"The use of producer gas with extraordinarily high sulphur contents causes no injury to the cylinders of gas engines.

"The extensive use of sulphur compounds in the tanning industry would have very much greater tendency to cause deterioration of leather than the slight amounts of sulphur gases coming from illuminating gas.

"The concentration of sulphur dioxide along with water vapors on the walls of rooms have some antiseptic value.

"People exposed to sulphur dioxide in high concentrations, as in sulphite paper mills, enjoy usual good health and show no ill effects from such exposure."

* * *

In this connection it will be interesting to review briefly the methods of removing sulphur from gas. The following notes are taken from another report of Mr. ARTHUR D. LITTLE:

In a general way, 60 per cent. of the sulphur in coal remains behind in the coke. The great mass of the sulphur leaving the retorts with the gas goes in form of hydrogen sulphide, the percentage of the sulphur in this form being between 80 and 95 per cent. of the total. The rest is gaseous sulphur compounds, of which the most important is carbon bisulphide.

The removal of hydrogen sulphide by the condensers and scrubbers depends in a large measure upon the way in which these are handled. With the use of fresh water in the scrubbers, but little hydrogen sulphide is taken out; if a strong ammoniacal liquor is used, much carbon dioxide and hydrogen sul-

be removed. The following results were obtained [illegible] weld, where fresh well water runs into the scrubber [illegible] liquor is obtained at the outlet:

Inlet		Outlet	
Hydrogen Sulphide.	Sulphur Compounds.	Hydrogen Sulphur.	Sulphur Compounds.
680	32.7	620	32.0
615	34.7	580	33.6
730	33.2	690	32.7
590	37.7	560	37.2

When coal gas was first manufactured, it was found that the amounts of hydrogen sulphide which it contained were so great as to render its use impracticable unless this compound could be removed. Its removal in the early days of gas manufacture was effected by the use of lime.

A marked step in advance was made when it was found that this objectionable compound could be removed almost completely by passing the gas through the oxide of iron which reacts with the hydrogen sulphide forming sulphide of iron. When this reaction has proceeded to such an extent that the iron becomes largely converted into sulphide, it must be removed from the purifying boxes and exposed to air.

By this means a second reaction takes place with the regeneration of oxide of iron and the deposit of free sulphur. In this way the oxide can be used over and over again until the percentage of sulphur becomes too high for use in purification. In some cases the oxide, rich in sulphur, is then sold to sulphuric acid manufacturers.

Hydrogen sulphide reacts with lime to form sulphide of lime and some of the more complex lime sulphides. Since, however, the affinity of lime for sulphur is less than for carbon dioxide, the lime sulphur compounds are decomposed by the carbon dioxide of the gas, setting free hydrogen sulphide, which again passes into the gas stream. On this account the action of lime is unreliable.

As the gas enters the lime purifiers the first thing to be absorbed is the carbon dioxide, and consequently near the entering point of the gas the lime is all converted into carbonate. As this reaction proceeds, the lime further and further along the course of the gas is converted into carbonate and the hydrogen sulphide which has previously been absorbed is set free, so that it may happen that gas leaving the lime-purifier box contains considerably more hydrogen sulphides than when it entered.

Changes in the efficiency of the condensers and scrubbers as carbon dioxide removers, or any changes in the retort process whereby more carbon dioxide is formed, will tend to prevent the removal of hydrogen sulphide of lime. So far as the hydrogen sulphide is concerned, it is not an important matter since the oxide purifiers are so much more efficient, and can be relied upon to take care of this compound.

Gas which has been purified by oxide is usually practically free from hydrogen sulphide. That it is absolutely free in a chemical sense is not probable, but the amount is very much less than a grain to 100 cu. ft., and, for all practical purposes, is negligible.

Various tests of purified gases have been proposed. In one of these the stream of gas is made to impinge upon a dry-lead acetate paper during the time in which the reforce sulphur test is in progress, which means for a good many hours. In another method the gas is tested for three minutes with a moistened lead-acetate paper. In either case the formation of a black stain shows the presence of appreciable amounts of hydrogen sulphide, and is usually regarded as condemning the gas.

Hydrogen sulphide in gas is regarded as being more injurious than the other sulphide compounds since it tends to attack brass fittings, etc., with which the unburned gas comes in contact. On combustion, of course, it is no more harmful than any other sulphur constituent of gas since it changes entirely into oxide of sulphur.

Purification of Gas from Sulphur Compounds other than Hydrogen Sulphide.—Pure iron oxide has no absorptive capacity for carbon bisulphide or the other so-called sulphur compounds. The oxide may through repeated use accumulate considerable percentages of free sulphur. Free sulphur is soluble in carbon bisulphide, and carbon bisulphide is absorbed by it to some extent. The amount of absorption would probably be influenced by the presence of other gases, and particularly by the temperature. It has been recognized by gas engineers for some time that the oxide containing a fairly high percentage of free sulphur has some value in the removal of sulphur compounds, but the action of the oxide purifiers is not relied upon for this purpose.

Neither oxide nor hyroxide of lime has any absorptive capacity for the sulphur compounds other than hydrogen sulphide. New, clean lime, therefore, when first put into use is of no value for sulphur purification.

When, however, the hydrogen sulphide is absorbed by the lime, with the consequent formation of the calcium sulphides, it shows a marked and somewhat uncertain capacity for the absorption of the sulphur compounds. Just what that reaction is, is not altogether clear, although the most probable view is that the calcium hydroxyhydrosulphide absorbs carbon bisulphide, forming calcium thiocarbonate. It, therefore, follows that for the removal of sulphur compounds it is necessary to have a lime box which is foul from the absorption of hydrogen sulphide. It frequently happens that for no cause which the gas engineer can learn a lime box refuses to perform its function of absorbing sulphur compounds, and the unknown character of the products of reaction have long worked against very accurate scientific control of this process.

The spent lime, which has been converted into carbonate from the carbon dioxide of the gas, has no absorptive capacity for sulphur compounds.

As Mr. Little points out, it is the most universal testimony of gas engineers that one of the most harassing things about gas manufacture is the worry and difficulties incident to the removal of the sulphur compounds. This is an entirely different matter from the ordinary control of purifying boxes, such as oxide purifying boxes, and the reason for the attitude of gas engineers toward the removal of sulphur compounds is due to the unreliability of the whole process as at present conducted.

A number of causes work together to produce this uncertainty. The composition of the sulphur compounds is not well understood. The unpurified gas, as it leaves the retorts, contains variable quantities of these sulphur compounds, and these variations are partly due to obscure causes.

Aside from the fact that carbon dioxide converts the lime into a carbonate which has no absorptive capacity for sulphur compounds, this gas is liable to make sulphur purification uncertain by decomposing the lime sulphides, sending forward into the stream of gas not only the hydrogen sulphide, which would then have to be absorbed by the iron oxide, but also the carbon bisulphide which has been held by the lime-sulphur compounds. Any changes in the processes of firing, condensation or scrubbing, which tend to let through an unusual quantity of carbon dioxide, may upset the whole course of lime purification.

A case in point was the new Beckton works of the Gas Light & Coke Company, of London, for which a very large purifying plant has been installed. But the degree of purification was unsatisfactory, and only after a long investigation it was discovered that the purifying apparatus was ample, but that the condensing and scrubbing system was too small, so that the carbon dioxide was not being removed as thoroughly as it should have been.

The referees showed by analytical work at the various London gas works that the scrubbers were, or should be, fairly efficient removers of the carbon dioxides. On account of the lack of the removal of carbon dioxide at the Beckton works this gas was going forward in unusual amounts and decomposing the

lime sulphides so rapidly that the carbon bisulphide was not being thoroughly removed.

Here was an instance of a case where the very best gas engineering talent in the world was unable for months to diagnose the real cause of the imperfect purification, and illustrates the obscure character of the difficulties which may confront the engineer in the removal of the sulphur compounds.

Notes.

Chile Saltpetre.—According to a recent consular report, the Delegacion Fiscal, or Official Board of Engineers, has reported to the Government of Chile that in their former estimates the amount of available sodium nitrate deposits has been underestimated. "There are undeniably 4,843,000,000 Spanish quintals of sodium nitrate in sight, which by the methods in use at the present time may be produced from the lands measured and estimated in the nitrate region. With an annual exportation of 35,000,000 quintals, which is more than exported in 1907, there is sufficient to satisfy the entire consumption of the world for 130 years."

The New Copper Process of Mr. Lawson.—The latest undertaking of Mr. Thomas W. Lawson, of Boston, is the offering of the stock of the Santa Rita (New Mexico) Mining Company and the announcement that a new hydrometallurgical process of Mr. Charles S. Bradley is to be applied. Mr. Bradley's former important work in the field of electrochemistry has been sketched in our Vol. I, page 451. He is probably best known by the Bradley internal heating patent which played such an important part in the aluminium patent litigation, and by the Bradley-Lovejoy process for the fixation of atmospheric nitrogen, which was a commercial failure at Niagara Falls, but, nevertheless, marked the beginning of this new industry which has since (with other processes) proven successful in Norway. It is a pity that Mr. Lawson's big book does not give any further indication of the new Bradley copper process, except the statement that the process is being applied on a practical scale within a gunshot of New York, probably meaning experimental work which is reported as having been performed at the celebrated tin smelter in Bayonne, N. J., which never started operation. Mr. Lawson states, however, that former reports to the effect that this process extracts 100 per cent of the copper of the ore are not true, but that it permits the recovery of "a very large proportion of the copper which remains in any ore after every known process has extracted the copper up to its limit."

Seventh Annual Congress of Applied Chemistry.—The congress which is being held from May 27 to June 2, 1909, at London, has attracted a large number of delegates from this country. This is especially pleasing as the present congress will receive an official invitation to meet the next time—in the spring of 1912—in New York City, as has been repeatedly mentioned in these columns. It seems now certain that this invitation will be accepted. From a cable dispatch to the New York *Sun* we note that Ambassador and Mrs. Reid gave a dinner to the American delegates. A reception followed. Several hundred Americans attended the reception, as well as representatives of various foreign embassies. At one of the first sessions of the section on legislation, Dr. Hugo Schweitzer, of New York, said that inventions should find international recognition. For the benefit of inventors international rules and regulations should be established. He moved that an international committee be appointed to consider and draft proposals for joint international patent and trade-mark legislation with a view to international uniformity, such proposals to be submitted to the international congress of 1912 for discussion and further action. The resolution was carried unanimously and a committee was appointed. Our full report of the proceedings of the congress must, of course, be deferred to our next issue.

Personal.

Mr. **J. E. Johnson, Jr.**, has resigned as general manager of the Princess Furnace Company, at Glen Wilton, Va. Mr. Johnson has distinguished himself by his early work on the dry-blast process. In a paper read in 1905 before the American Institute of Mining Engineers, he discussed the physical action of the blast furnace and suggested that the chief difficulties in the existing blast furnace could be reduced, if not eliminated, by the oxygen blast.

Mr. **W. A. C. Tape** has resigned as resident manager of the Metallic Alloys Company, of Elkton, Va. (successors to Kendall & Flick). While in this position, Mr. Pape designed, built, and put into successful operation a dry-grinding mill for the treatment of manganese ores, as well as a small smelter for the manufacture of manganese-copper.

Mr. **P. B. Sadtler**, S.B., chemical engineer, formerly of Philadelphia, has been added to the staff of the Swenson Evaporator Company, with offices at 945 Monadnock, Chicago. Mr. Sadtler's experience of several years in evaporating lines, as well as his knowledge of the paper pulp business; manufacture of electrolytic caustic and heavy chemicals and caustic recovery from "black" liquor, mercerizing solutions, etc., will make this company especially strong in these departments. Mr. Sadtler was formerly connected with the West Virginia Pulp & Paper Company and the Geo. M. Newhall Engineering Company.

Mr. **A. H. Reed** has resigned as mine superintendent with the Longdale Iron Company, Longdale, Va., and has accepted a position as mining and mechanical engineer with the Independent Phosphate Company, Columbia, Tenn.

Obituary.

C. I. Zimmerman died in Madison, Wis., on May 15. While on the lake his boat capsized and after being some time in the water he was rescued, but died shortly afterward as the result of the exposure. Mr. Zimmerman was formerly an engineer of the Carborundum Company, of Niagara Falls. During the past year he did post-graduate work at the University of Wisconsin. He has contributed various papers to the American Electrochemical Society, especially on electrolytic condensers. He attended the recent meeting of the society at Niagara Falls, and presented on this occasion an elaborate paper on the physical properties of silicon.

Digest of U. S. Patents

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC FURNACES (*Continued*).

No. 587,343, August 3, 1897, George S. Strong, of New York City

Arc type, especially designed for the production of calcium carbide. The charge, for example a mixture of lime and carbon, contains sufficient coal-tar or molasses to render it plastic. The plastic mass is forced from hoppers, by pistons, through opposite horizontal cylinders having tapering ends and compression rolls, into and out from opposite aligned dies, which form the plastic material into electrodes. The arc is sprung between the ends of the ejected portions of the charge, the electric current being supplied to the metal dies. The movement of the pistons and rate of feed of the plastic material is electro-magnetically controlled. A chamber beneath receives the melted product, being provided with an outlet having horizontal gates at different elevations to permit discharge without admission of air. One side of the smelting chamber has a glass door to permit inspection and the introduction of a saw to cut the electrodes apart in case they fuse together. One or more ingredients of the charge to be smelted may be fed downward

directly into the arc from a valved hopper depending into the smelting chamber.

No. 597,645, Jan. 25, 1898, Charles S. Bradley, of Avon, N. Y.

Arc type, especially designed for the production of calcium carbide. The furnace is a wheel, or annular trough, of sheet iron, to which may be attached a series of outer metal sections, the whole forming a circular receptacle 3 ft. in transverse diameter, for a wheel 15 ft. in diameter. The wheel rotates on a horizontal shaft, the series of removable sections being secured to its lower half, constituting the smelting and carbide-cooling chamber, and the upper half of the annular trough being open and empty. A carbon electrode about 4 in. in diameter, and vertically adjustable, depends into the circular smelting chamber at one side of the wheel, and a series of radial copper plugs project from the bottom of the annular trough at regular intervals, these plugs being electrically connected to a commutator on one end of the wheel-shaft, on which bears a brush connected to one pole of the electric generator. In starting the furnace, a body of carbon in placed between the depending carbon electrode and the adjacent copper plug, the wheel is then rotated downward from the carbon electrode, starting an arc, and the mixture of lime and carbon is thereafter continuously fed in, the ingot of calcium carbide subsequently serving as the lower electrode and carrying current to the copper plugs. According to a modification, two depending carbon electrodes may be employed. The wheel makes one rotation in five days. From time to time, a removable half-section is taken off from the trough, at the rear of the wheel, permitting the outer layer of unreduced material to fall away and exposing the solidified core of calcium carbide, pieces of which are periodically broken off.

The electric arc is formed wholly within the mass of pulverized charge, and a wall of unreduced material surrounds the product, air thus being excluded until the product cools. The surrounding layer of unreduced material acts as an effective heat-insulator.

No. 598,318, Feb. 1, 1898, James E. Hewes, Philadelphia, Pa.

Resistance type, especially designed for the production of calcium carbide. The mixture of lime and carbon feeds downward from the bottom of a hopper through a top opening in a horizontal circular iron tube, in which reciprocates an iron rammer. The charge is thereby intermittently fed forward out of the end of the tube and between and in contact with flat carbon electrodes, pivoted to swing horizontally to and from each other. The current employed may be from 1500 amp to 2000 amp. at from 100 to 110 volts. The reciprocation of the rammer and rate of feed is electro-magnetically controlled. The carbide slides down an inclined floor, whereon it cools, and onto a grate through which the unreduced material falls. Both electrodes are completely imbedded in the charge, thereby protected from oxydization by air.

No. 602,815, April 19, 1898, George E. Clark, of Galveston, Tex., assignor to S. Blum, H. Eldridge, D. J. Clark and S. Lazarus.

Arc type, especially designed for the production of calcium carbide, but useful for the production of metal oxides generally. The furnace chamber is a circular pan of iron, mounted to rotate on a vertical central shaft beneath. The pan is lined at its bottom with a plate of carbon, which constitutes one electrode.

The other electrode is a depending carbon rod, the upper end of which is secured by set screws in a metal tube which is vertically adjustable. A feeding plow consisting of a vertical metal plate of about the same depth as the pan surrounds the lower end of the depending electrode and is bent helically inward toward it. This plow carries a protecting hood, depending over the pan. In operation, the plow is lowered and feeds the charge inward toward the arc, being raised to decrease the feed and gradually adjusted until the desired amount of carbide is produced. The upper electrode and plow are then raised and the ingot of carbide removed by crane and tongs.

No. 603,053, April 26, 1898, H. Eldridge, D. J. Clark and S. Blum, of Galveston, Tex.

Arc type. A retort for manufacturing hydrogen gas from water. The retort is a cylindrical cast-iron pot, lined with carbon and hermetically closed at the top by a cover having a stuffing-box. The vessel constitutes one electrode and a vertical carbon rod passing through the stuffing-box constitutes the other. Water is pumped into the pot near the bottom, at one side, by a pipe having a check-valve, is decomposed by the heat and electrolysis into hydrogen and oxygen, the oxygen combines with the carbon of the lining and electrode to produce carbon dioxide, and the mixture of gases escapes through a pipe to a gasometer, having a water seal which absorbs both the major portion of the carbonic-acid gas.

BOOK REVIEWS.

Handbuch der Elektrotechnik. Edited by Prof. C. Heinke. Vol. XI, part II: Warmetechnik und Signalwesen. By V. Engelhardt, K. Hohage, H. Freytag, H. Schwerin and R. Vogel. 560 pages, 541 illustrations and 26 plates. Leipzig: S. Hirzel.

This monumental German handbook of electric engineering, which is unique in scope and character and will be a credit to the profession when finished, is published in parts, each written by an authority in the field treated. Such a system has both advantages and disadvantages. The information given is authoritative, though it may be occasionally biased on account of the personal relations of the author to the industry. Further, each volume has its own individual character, which is a distinct advantage for that volume, though the whole handbook becomes thereby somewhat unbalanced.

The present Volume XI, Part II, is of a very heterogeneous character. Almost half of the volume is filled by the chapter of V. Engelhardt on electrothermic apparatus and processes. The balance is devoted to chapters on electric blasting in mines by Dr. K. Hohage, on fire-alarm signals by H. Freytag, on electric railway signals by H. Schwerin, and R. Vogel on block signals.

The contents of the last-named chapters indicate a wide-reaching specialization in the arrangement of the handbook. It is to be regretted, therefore, that Mr. Engelhardt's chapter on electrothermics has not been divided into two separate chapters; as it is, it comprises electric heating, cooking and welding processes as well as electric furnaces. Though based on the same principles, the apparatus and methods of both industries are very different.

Mr. Engelhardt is in charge of the electrochemical department of the Siemens & Halske Company and has been intimately connected with the development of the induction furnace. He is, therefore, in a position to write a creditable work on electric furnaces and he has certainly succeeded in doing so. The text is clear and the illustrations are excellent.

The weakest point seems to us the classification employed. It may be correct in theory, but it brings things together in the same chapter which are of a very different character. On the other hand, for instance, Héroult's furnace is to be mentioned both in the resistance furnace chapter and in the arc furnace chapter, as an indication of the fact that such a division of electric furnaces is quite easy on paper, but that it is not always easy to decide whether a particular furnace belongs to one or the other type. As to references to existing literature, it is to be regretted that Engelhardt almost exclusively refers to German books or publications which in many cases do not contain first-hand information.

Although the chapter was up to date when written, it is quite possible that when the whole handbook is finally finished Mr. Engelhardt's chapter will be the first one that will need revision, so rapid is just now the progress of the electric furnace, especially in the steel industry.

The volume is decidedly worth a place in the library of engineers interested in electric furnaces.

Electrochemical and Metallurgical Industry

Vol. VII. New York, July, 1909 No. 7

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York
European Office, Hastings House, Norfolk St., Strand, London, Eng.

J. W. Richards, Ph.D.....*President*
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C. E. Whittlesey.....*Treasurer*

Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

New York, July, 1909.

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Chemical and Metallurgical Geography.

Mr. Harriman has been accused of many things by the newspapers. So it was nothing extraordinary to hear a speaker at a recent American Electrochemical Society meeting remark that, after all, it is Mr. Harriman who decides whether a chemical reaction or a metallurgical process shall work and be a commercial success. Commercial success depends on two elements—cheap production and cheap distribution or an easy market. The question where to locate a plant so as to eliminate as far as possible Mr. Harriman and reduce transportation expenses, must be decided in each case on its own merits. It is often advisable to divide the whole metallurgical process into several steps and erect two plants. Thus in zinc metallurgy, because two or four tons of coal are needed to treat one ton of ore, it is cheaper to ship the ore than the coal. Hence, the zinc smelter will be placed near a coal field, but to reduce the tons of zinc ore to be shipped, a mechanical or magnetic concentrating plant is placed at the zinc mine. Or in copper metallurgy, we have the smelters in the West, but the refineries near the market at New York Harbor.

* * *

The problem of finding the best location of a plant is always exceedingly complicated. Of the transportation expenses—which are often a very big item, not only in distribution, but also in production—we have spoken. Then comes the power cost, the labor problem, and all the other items which enter naturally into production and distribution. Then there may be considerations in connection with protective duties. As a monumental example of the lack of foresight in this respect there stands, idle for years, in Bayonne, N. J., a large tin smelter, which never started operation because the expected ore supply from the Straits Settlements was cut off by legal provisions keeping the ore in the Settlements. But this is an exceptional case. In electrochemical industries the cost of power is often of very decisive importance. Hence we have the large centers of electrochemical industries at Niagara Falls, in Savoy, France, and now at the Norwegian coast, where immense water-powers are available and shipping facilities by ocean steamers are excellent. It is quite natural that the new electric furnace industry of making nitrates and nitric acid from air is settling down in Norway. With respect to raw materials this industry is not bound to any locality, since air is everywhere available. But this industry needs, above everything else, very cheap power. This is available in Norway. Then the industry needs a market for the products; this is supplied chiefly by other countries, the transport by ocean steamers being cheap. If this industry shall settle down in this country, the transport facilities will have to be taken into account as the decisive factor. With respect to cheap power we can hardly expect to compete successfully with Norway.

Atomic Weights.

The article by Dr. Hinrichs, published in this issue, appears to call for a word of introduction. We believe that everybody who earnestly and honestly searches after truth should have his say, and since Dr. Hinrichs has not had an opportunity to present his views in American chemical journals for many years past we have been very glad to place our columns at his disposal. The importance of the subject is beyond question, even for applied chemistry. Dr. Hinrichs' theory is an exceedingly clever and interesting elaboration, with many important modifications, of the old hypothesis of Trout. But Dr. Hinrichs has so far been very decidedly in the minority. To sketch impartially the situation, we cannot do better than quote the concluding words of a review of a former book of Hinrichs, written by Dr. Wilder D. Bancroft in his *Journal of Physical Chemistry* Vol. VI, page 59: "The reviewer is not as yet prepared to say that Mr. Hinrichs is right in his conclusions, but it does seem as though the question of the atomic ratios was distinctly an open one. It seems also as though it would be profitable to science if some of the data accepted by Mr. Hinrichs should be verified and that work of this sort is of far more immediate importance than to determine the atomic weights of a large number of elements. There is another way of looking at this matter which may be profitable. What does the fact that the views of Mr. Hinrichs have not been accepted prove in regard to their accuracy or inaccuracy? Absolutely nothing at all. The natural conservatism of scientific men is so great that a revolutionary truth has to fight its way and to fight hard. Mr. Hinrichs has never made any atomic weight determinations himself, nor has he ever had students who have done so. This has been fatal to the acceptance of his views, but it has proved nothing in regard to their merit. The question at issue is not one of manipulation, but of the critical interpretation of results. The man with great manipulative skill may also have a highly developed critical sense, but it is not necessarily the case and the two faculties are quite as likely to be found separately as together. Consequently, two of the arguments against Mr. Hinrichs fall to the ground, namely, that his views must be wrong because they have not met with favor and that he is not qualified to judge because he has never shown his ability to make atomic weight determinations. The whole question is, therefore, open and can be broadly stated as follows: Do the methods approved by Hinrichs give the results he thinks they do?"

* * *

Since these words were written by Professor Bancroft five years ago, much important work has been done by skillful, conscientious and enthusiastic experimenters. On the other side, Dr. Hinrichs has continued his analysis and interpretation of the experimental results of others. His article in this issue, and especially the table summing up on a single page the results of many years of experimental work, will prove exceedingly interesting reading, even if one disagrees with the polemical portions of the paper. This journal is no party in this controversy. No man, nor method, has a monopoly of searching after truth. The finding of truth is always the result of a clashing of ideas. It is unnecessary to add that after we have gladly placed our columns at the disposal of Dr. Hinrichs, they will be open to the other side for a reply. And we sincerely hope that a general clearing of opinions will be the ultimate result.

Liquid Chlorine.

For many years the great Badische Anilin und Soda Fabrik, in Germany, has liquified electrolytic chlorine for its own use as an oxidizing agent in the manufacture of coal-tar dyes, and has also sold its surplus product. Other large German chemical concerns have likewise produced liquid chlorine. But heretofore the stamp on the cylinders of liquid chlorine used in this country has always been "Made in Germany." At the present time, however, at least three of the concerns in this country which decompose brine in the electrolytic cell are preparing to dispose of this product as liquid chlorine. The manufacture of liquid chlorine out of the gas presented at first several serious difficulties. But by employing several stages of cooling and compression, by drying the gas so absolutely that its corrosive properties are nullified, the process lost its serious troubles and has been reduced to a practical basis.

* * *

There is no danger in the use of liquid chlorine. In fact, the flow of gas can be controlled by the outlet valve with perfect and surprising ease. In Germany the liquid chlorine has been transported in tank cars without any accidents of a serious nature. The uses of liquid chlorine are many, for it can replace bleaching powder almost in every instance. For bleaching in textile mills, for making stannous chloride out of tin scrap, in the artificial dye industry, in the chemical works as a perfect oxidizing agent, and in chlorinating gold ores, in all these cases liquid chlorine can be adopted as a substitute for bleaching powder. In addition, in every analytical laboratory liquid chlorine when once used will be found to be indispensable. There are a great many practical difficulties inherent in the absorption of chlorine by quicklime in chambers especially in weather like that prevalent recently. In addition, over 10 per cent of the chlorine is often reduced to calcium chloride, and is thus rendered unavailable. The cost of lime is high and the cost of the package for the bleaching powder increases the cost to the consumer of the "great oxidizer."

* * *

With cheap power, the cost of compression of chlorine is not large. And every electrolytic caustic-chlorine plant has cheap power. The cylinders for the liquid chlorine should be made seamless and hence the first cost for them, as well as for compression plant, is somewhat high. But when these are once amortized, the charge is, of course, small. Ultimately there will be a great national gain when liquid chlorine replaces bleaching powder in this country's great industries. And this result will be reached slowly, but surely, for economic pressure overcomes "commercial inertia."

Keeping Watch in Concentrating Plants.

It is with particular pleasure that we call attention to Dr. Rudolf Gahl's paper in this issue on calculations in ore concentration. With the rapid growth in the size of modern industrial and manufacturing plants, it has become of utmost importance to exert one's self to keep close watch of the whole operation and all its details. Elaborate book-keeping methods, indicating and recording instruments have become of widest

use. The simplest case is probably found in an electric generating plant, if we consider the electrical part alone, where the use of indicating or recording voltmeters, ammeters, wattmeters, etc., gives directly and easily all the information desired. It is much more difficult in boiler plants and metallurgical furnace plants; but the rapidly growing use of carbon-dioxide recorders and of pyrometers means a great simplification of the operation and a much more rigid control than was formerly possible. In ore concentrating plants, where very large values are at stake, no such simple recording instruments are available. We have to rely chiefly on screen tests and assays.

* * *

Screen tests and assays need interpretation. Thus the personal equation comes in. This is a disadvantage and an advantage. We like recording instruments, for instance, chiefly because they are impersonal, because they give us a permanent impartial record. This is a very great advantage, but we should not overlook the possibility of an instrument reading wrong; and if such a case occurs, it will read wrong always in the same direction; this is part of its impartiality. With human beings it is different. We can assume with a certain degree of probability that the mean of a number of assays is about right. But assays and screen tests need interpretation; that means work, conscientious and careful thinking. An ordinary workman can read an instrument. The interpretation of assays and screen tests—if carried out to its limits, as shown in Dr. Gahl's paper—requires a good engineer. Although the error in screening expressed in percentages may be greater than the error in assaying, there are cases in which the results based on screen tests are much more reliable. It is for the chemical engineer to decide that in each case.

* * *

As Dr. Gahl shows in his paper, we can check the results of assays against the results of screen tests. Or we may figure the "saving" of a concentrating mill (the ratio of valuable metal in the concentrates to the valuable metal in the ore) from assays of heads, concentrates, and tailings alone, or we can find the same figure from the assays in combination with the weights. We have, in all, four ways of calculating the saving and checking the result. And thus we eliminate the personal equation. All these calculations, as Dr. Gahl shows, require very simple mathematics only. But they require some engineering judgment. The moral of Dr. Gahl's paper is that if assays and screen tests are made in a concentration mill, it is the clear duty of the engineers in charge to make the utmost of these assays and tests, by extracting, with the aid of simple calculations, all the technical information that is hidden therein—concerning the saving, the rate of concentration, the distribution of pulp in the mill, etc.

A Bit of Friendly Criticism

Robert Burns, Scotland's national poet, made in his quaint old dialect the very pointed query, "Oh, wad some power the giftie gie us to see ourselves as others see us." This is applicable to each and every one of us. It is likewise apropos of nations and it is interesting to see what other nations think of us. Nations, just like individuals, rarely have the "giftie" so requisite for correct self-judgment. For a nation, philosophically considered, is an individual, it has a physical body and an inspiring soul. Probably the general reading public in America know about as little about finance and political economy as about anything else. Hence the comments of the European financial journals about American industry are interesting, for they are sane and fair, even though they are imbued with old-time conservatism and do not fully appreciate the marvelous recuperative powers of this youthful nation.

* * *

One of the most impartial of these periodicals—the "Economiste Français"—is now looking upon our immediate industrial future with smiling eyes and a beaming countenance. But at the same time it utters a note of warning and caution. Our increasing railroad earnings with net increasing faster than gross, the revival in the building trades especially in the West, the "telling of the tape" in Wall Street, where the discounting of the future is made a business, all these our Gallic contemporary believes to be the "signs of the dawn." It also points out, quite pertinently, we should say, that "if all the panic's consequences are not yet effaced, if the patient still needs a moderate diet, and if his best wishers still hope that he will not indulge too quickly in the violent agitation of a boom, nevertheless health is returning to his organism." This expresses almost precisely the views of this journal so often given in these columns. Thus modesty forbids us doing more than commending the good common-sense of the "Economiste Français" in looking at our country with the idea of proportion, with a sense of our underlying strength rather than, as so many foreigners do, mere scrutinizing in the hope of finding minor superficial defects.

* * *

In conclusion, the French journal points out the importance of our having good crops this year to finish the sinews of war for "the prodigious industrial impulse recently developed," though it admits that we are each year less and less of an agricultural community, and hence not so dependent as formerly on good crops. "Such an accident as poor crops," it continues, "will not stop recovery, that is dependent on the wisdom and good sense of the Americans. They must not yield to the tendency to go too fast. If they are willing to move ahead at a prudent pace, they have a growing prosperity ahead." This is all admirably to the point. It is good advice and friendly counsel. For our own part, let us say that the United States as a nation is endowed with remarkable originality, with great energy, and with what the Germans call so expressively, "Geist." It has rich broad acres and enormous mineral wealth. The combination of great national resources and national physical vigor and mental energy makes for immense and rapid national growth. The reaction from the periods of growth is naturally more marked in this country, which grows so fast, than in a country like France, that is more or less stationary. But we as a nation are passing out of the period of adolescence, and it behooves us to conserve our powers and expand at a more uniform rate. Friendly criticism like this of the "Economiste Français" will help us to attain this end, for friendly criticism is the only kind to which most of us will listen.

International Congress for Mining and Metallurgy, Düsseldorf, 1910.

The last International Congress for Mining, Metallurgy, Applied Mechanics and Practical Geology was held in Liege, Belgium, in connection with the 1905 exhibition. In its last session the congress decided to accept the invitation of the manufacturers of Rhineland and Westphalia to hold the next congress there.

In accordance with this decision the congress will be called for the end of June, 1910, to Dusseldorf, Germany. Much is already being done in the way of preparations for this congress. It will last about a week. Besides sessions for the reading and discussion of papers, visits will be paid to scientific institutions and industrial plants, and excursions will be made to districts of geological interest.

Further details of the program of the congress and the exact date will be given later. Inquiries should be addressed, and titles of papers to be presented should be sent to the Arbeitsausschuss des Internationalen Kongresses Düsseldorf 1910, Jacobisstrasse 3, 5, Düsseldorf 15, Germany.

National Irrigation Congress.

The Seventeenth National Irrigation Congress meets in Spokane, from August 9 to 14 next, for the consideration of and action on irrigation, drainage, forestry, deep waterways, good roads and home building—all these subjects being of such importance for the solution of the problem of the conservation of our natural resources.

Mr. George E. Barstow, of Barstow, Tex., is president of the congress; Mr. B. A. Fowler, Phoenix, Ariz., secretary; Mr. R. Insinger, of Spokane, chairman of the board of control; and Mr. Arthur Hooker, Spokane, secretary of the board of control.

Association of Iron and Steel Electrical Engineers.

The second annual convention is to be held at Buffalo, N. Y., from June 23 to 26.

June 23 is designated as "Members Day." The president, Mr. John C. Reed, will present his address. The treasurer, Mr. E. W. Yearsley, and the secretary, Mr. G. H. Winslow, will present their reports. The reports of the Standardizing Committee and the Safety Committee will be read and discussed. Two lectures on the electric furnace are to be delivered on this day, one by Mr. E. W. Yearsley and the other by Mr. P. McN. Bennie.

June 24 is "Visitors' Day." The program for this day is as follows:

Westinghouse Electric & Manufacturing Company: Some Important Phases of Electrical Power for Steel Mills, by Mr. C. F. Scott; Motor and Control Apparatus for Steel Mills, by Mr. B. Wiley.

The Electric Controller and Manufacturing Company: A Steel Mill Starter for Direct-Current Motors, by Mr. C. Pirtle.

The C. J. Toerring Company: Flaming-Arc Lamps, Operation and Demonstration, by Mr. C. J. Toerring.

American Fuse Company: Allen-Bradley Controllers and Starters, by Mr. Lynde Bradley.

General Electric Company: New Developments in Electric Apparatus, by Messrs D. B. Rushmore, Pauly and Whiting.

Crocker-Wheeler Company:

Westinghouse Machine Company: Leblanc Condenser, by Mr. Edwin Yawger.

For June 25 visits are planned to various steel works, like the Lackawanna Steel Company, the Seneca Iron & Steel Company, also to other plants at Buffalo and vicinity.

On June 26 excusions will be made to Niagara Falls and its electric-power plants.

Brooklyn Meeting of the American Institute of Chemical Engineers.

While this number is going to press the Brooklyn meeting of the American Institute of Chemical Engineers has begun on June 24 under very favorable auspices.

The meeting, which is being held at the Polytechnic Institute in Brooklyn, was opened on June 24 by an address of welcome by Mr. Herman A. Metz, the Comptroller of New York City, and himself a manufacturing chemist, and by Prof. Irving W. Fay, of the Polytechnic Institute.

During the morning session two papers were read. Prof. W. D. Ellis discussed the limits of efficiency of the power gas producer, calculating theoretically the possible efficiencies with air alone, or with steam or waste gas added. The paper was discussed at some length.

Dr. O. K. Zwingenberger dealt in his paper with the utilization of low-grade fuels in the United States, discussing especially peat gas producers.

There was a short business session at noon while Mr. Jerome Alexander made an interesting demonstration of the ultramicroscope in an adjoining room.

The papers on the program for the afternoon dealt with creosote oil from water gas tar, by Dr. S. P. Sadler; case hardening of steel with gas, by Dr. J. C. Olsen; automatic acid egg, by Mr. Richard K. Meade; the centering of great industries in the New York Metropolitan District, by Dr. C. F. McKenna; methods of clay control, by Mr. J. G. Dean. After the exceedingly hot day a subscription dinner was greatly enjoyed in the evening at the Brighton Beach Hotel.

The program for Friday, June 25, and for Saturday, June 26, contains various interesting excursions. Friday a visit is first paid to the Atlantic White Lead and Linseed Oil Works in Brooklyn, from there the party is taken by steamer up the Hudson River, with visits to the Edgewater plant of the Corn Products Refining Company and the Edgewater plant of the Warner Sugar Refining Company.

Among the excursions scheduled for Saturday, June 26, is one to the Standard Oil Company's plant at Bay Way, N. J., and to the plant of the Consolidated Gas Company at Astoria, L. I. We reserve for our next issue a full report of the meeting with abstracts of all the papers presented.

National Electroplaters' Association.

At the second meeting of the National Electroplaters' Association of the United States and Canada, held in New York City on May 7, the were 28 members present. The president is Mr. Charles H. Proctor, supervisor, F. H. Lovell Company, Arlington, N. J.; the secretary is Mr. Benjamin Gilchrist, foreman plater, Lalance & Grosjean Manufacturing Company, Woodhaven, N. Y.; the treasurer is Mr. Nathan S. Emery, foreman plater, Victor Typewriter Company, New York.

The Iron and Steel Market.

The finished steel trade has reached a rather quiescent stage as to new buying after a period of great activity. When the general drop in prices occurred immediately upon the announcement of an "open market" February 18, there was very litttle buying. In the course of two or three weeks, shading began to appear from the prices as originally reduced, and gradually a general buying movement was inaugurated which rapidly gained in intensity. The total transactions in March probably did not exceed the average of last year, while April business greatly exceeded that of March, and May again showed a great gain over April. The total tonnage booked in March, April and May, partly in contracts and partly in definite orders, was equal to considerably more than three months' full production. In June this new buying was reduced to very moderate propor-

tions as regards jobbers and general consumers, but a new interest—the railroads—bought more heavily in June than they had in any of the immediately preceding months. In the closing days of April and during May there were a number of price advances, covering bars, plates, shapes, wire products and light rails.

In the heavy buying movement, the object of jobbers and consumers was to take advantage of the specially low prices available and to cover for some distance ahead. The mills, in making specially low prices, desired to obtain specifications for immediate rolling. At the outset the general tendency was to limit the low prices to material which would be taken out before July 1. Later the lines were less closely drawn, and contracts were entered with the proviso that a certain tonnage should be specified prior to July 1. It is generally admitted that in this movement buyers obligated themselves to specify a greater tonnage of material before July 1 than they would actually need. In a sense, this excess was speculative, while to an extent it merely involved an increase in current stocks in the hands of jobbers and consumers from an extremely low level to a level more in keeping with the amount of material being moved.

The production of steel has been steadily increasing to meet the specifications received, until at the close of June the steel industry proper is producing a tonnage within about 90 per cent of the greatest ever attained. The production of pig iron has reached a rate between 80 and 85 per cent of the maximum, the difference between pig iron and steel production being due to the fact that the foundry industry, which in 1907 consumed about 30 per cent of the pig iron made, has not reached the same degree of activity as the steel industry proper.

The beginning of July is evidently a crucial time in the steel industry. By reason of the terms of many of the contracts entered, buyers have been specifying, and mills have been running at a greater rate than the actual rate of consumption, but how great the excess is cannot be determined. After July 1, the requirements that buyers shall specify will partly disappear; but should the rate of specifying immediately decline, the result would not be felt immediately in production, because July 1 finds an accumulation of specifications. As a general average, it is probable that mills have actual specifications for from three to five weeks' solid work.

With no change in the rate of actual consumption, it might easily occur that specifications entered during the third quarter would show a material reduction, and production of steel would have to decrease. This possibility is recognized, but an optimistic feeling is professed in the steel trade, based chiefly on the expressed expectation that the actual rate of consumption will steadily increase.

As to the reasonableness of this expectation there may be some question. With steel products being made at a rate about 90 per cent of the highest ever reached, it remains the fact that the production of railroad material is far below the maximum, and without any close analysis of percentages it must be admitted that the rate of producing materials outside of those used by railroads actually exceeds the maximum ever attained. It might be regarded as difficult to break the previous record, with general business in a more or less depressed condition, but on the other hand, the iron and steel trade has repeatedly found, on emerging from a period of depression, that consumptive requirements have grown meanwhile, so that when normal conditions are restored they involve a larger tonnage than formerly.

Railroad Buying.

There was a concentration of railroad buying during June, large orders being placed for rails, cars and locomotives. The aggregate has been large, for a single month, and the reports of individual transactions have made quite a formidable showing. Such transactions, during a limited period, afford little guidance as to prospective rate of production, because deliveries may be required slowly. They do show distinctly the tendency of buyers, but there is some question as to the fundamental cause of the tendency when shown. It would be idle to deny that the general business situation is a highly speculative one, as evidenced in particular by the manipulation of the stock market, and in this general situation it is far from unreasonable to suspect that the tendency on the part of certain railroad interests to buy may be based more upon a desire to create a favorable showing for business than upon a desire to receive and at once use the material bought. Thus it has been reported that while the Harriman lines contracted for about 150,000 tons of rails during June, deliveries are not to commence until the fourth quarter.

Summing up, then, it may be said that while prospects are that general business and the actual consumption of iron and steel will continue to improve, it does not follow that such improvement will require a greater rate of output of iron and steel than has been witnessed in June. The present situation is, in a measure, artificial, and by so much as this artificiality is not being recognized at this time, the iron and steel trade, with its present extreme optimism, may be laying the foundation for one of those reversals in temper in the next two months which it has so often experienced.

Pig Iron.

There has been a sharp advance in pig iron in all markets, but particularly in the Central West. During the month prices in the valley market (freight to Pittsburg 90 cents) have advanced as follows: Bessemer, from $15 to $15.50; basic, malleable and No. 2 foundry, from $14.50 to $15, and forge from $13.50 to $14.25. Sales of foundry iron have been fairly large in the Central West, the East and the South, but in the immediate Pittsburg district have been relatively light. In the East there was a heavy movement in basic, following the buying in May, the total movement in the two months to Eastern steel works exceeding 200,000 tons. In the Central West, sales of basic have been fairly large. Bessemer has been neglected, outside the purchases of the Republic Iron & Steel Company and some small buying by other interests. Both basic and Bessemer in the Central West have been moving much more freely on regular contracts, based upon month adjustment according to the average market price. The minimum of the valley market at the close of the month is $15 on basic, No. 2 foundry and malleable, it being difficult to do these prices even for early delivery, while for third quarter or second half $15.25 to $15.50 is asked. Bessemer is at a minimum of $15.50, valley, while sales for fourth quarter would not be made except at an advance. Prices delivered Pittsburg are 90 cents above the market at valley furnace. The Southern market became decidedly firmer during June. In the forepart of the month No. 2 foundry could be purchased for early delivery at $11, Birmingham, deliveries over the third quarter being nominally $11.50. Towards the close of the month, all iron below $11.50 disappeared, this price being still quoted by a few interests, several important producers advancing their asking price to $12. In some quarters it is held that the Southern position is not fundamentally as strong as appears on the surface; that while the furnaces are technically sold up for third quarter, there is a question about the iron being taken on time, and that the appearance of any weakness would precipitate a selling movement which would promptly break the market.

Billets and Sheet Bars.

Early in June there was a heavy movement in sheet bars at cut prices. While the nominal price has been $25.50 for sheet bars, delivered Pittsburg, Wheeling, Youngstown, etc., sales were made for forward delivery at $24 and even at $23.50. Toward the close of the month the market firmed to $25 for Bessemer and $25.50 to $26 for open-hearth, the latter material proving to be relatively scarce. In billets, also, there is a mild scarcity of open-hearth, and premiums have been obtained in some cases over the regular price of $23, Pittsburg.

In Philadelphia billets are held at $25, delivered, and in Chicago at $24 to $25 delivered, the market at each point not showing the full freight advance over the Pittsburg price.

Finished Material.

There have been no important price changes in the month. Some mills have advanced their asking prices on bars to $1.25, and on plates and shapes to $1.35, but there are still sellers of bars at $1.20 and of plates and shapes at $1.30. Indeed, in exceptional cases, plates are sold at $1.25. A nominal advance in iron bars at Pittsburg was made from $1.30 to $1.45, not in the expectation that sales could be made at the advanced price, but in the hope of inducing better specifying on old contracts. This expectation has been realized in a measure. The market is quotable as follows, f.o.b. Pittsburg:

Steel bars, $1.30, base.
Iron bars, $1.45, base.
Plates, $1.25 to $1.35.
Shapes, $1.30 to $1.35.

Standard rails, $28 for Bessemer and $30 for open-hearth, f.o.b. mill; light rails, 25 to 45-pound, $25.50 to $27.

Sheets, 28 gage, black, $2.20; galvanized, $3.20.

Tin plates, $3.40 for 100-lb. cokes.

Merchant steel pipe, ¾ to 6-inch, inclusive, nominally 80 off in "jobbers' carloads;" actual inside price, 81 and 5 off.

Plain wire, $1.50, base; wire nails, $1.70, base; painted barb wire, $1.70; galvanized barb wire $2.00.

CORRESPONDENCE

Electric Resistivity of Fused Steel.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—In his recent American Electrochemical Society paper on the calculation of the Gin induction furnace, Mr. Gin gives the resistivity of steel in electromagnetic units. Practicing engineers, however, generally prefer to use the more practical units, namely, the ohm, cb. cm. or cb. in. units of resistivity, and as the conversion of one to the other is troublesome, in so far that errors are likely to be made, I have reduced his figures to practical units, and have taken the opportunity to add others for the sake of comparison and for giving an idea of the numerical values of these constants:

Material	Temp. C°	Resistivity		Conductivity	
		cm.	inch	cm.	inch
1 Fused steel...	not given	0.000,140	0.000,055	7,140.	18,100.
2 Fused steel...	not given	0.000,000	0.000,079	5,000.	12,700.
3 Fused cast iron	280-1340	0.000,16	0.000,063	6,502.	15,900.
4 Iron and cast steel	about 1300	0.000,114	0.000,045	8,750.	22,200.
5 Paddle steel...	15°	0.000,014.1	0.000,005.54	71,100.	181,000.
6 Bessemer steel..	15°	0.000,623.2	0.000,009.16	43,000.	109,000.
7 Pure copper...	15°	0.000,001,687	0.000,000,664	592,800.	1,505,000.

1. Gin. From present paper; lowest value 140,000 electromagnetic units.

2. Gin. From present paper; highest value 200,000 electromagnetic units

3. Gin. From his paper on "Note on the Electrical Resistivity of Iron and Steel at High Temperature," Trans. Amer. Electrochem. Soc., Vol. VIII., 1905, p. 289. This, I pointed out in the discussion, was a million times too small; this correction has been made here.

4. W. Kohlrausch. Landolt & Boernstein, 2d Ed., p. 468. The conductivity of cast steel at nearly white heat is given as 0.826 in terms of mercury at 0°, and that of electrolytic iron at yellow heat as 0.8196. Hence approximately 0.823 for either is near enough for the present comparisons.

5 and 6. Kirchhoff & Hansemann. Both taken from the L. & B. tables, 3d Ed., p. 716, in the form of the conductivity in centimeter units.

7. The Matthiessen value according to Lindeck, given here merely as a standard of comparison.

In the table, the resistivity units are in terms of the ohm, cb. cm. or the ohm, cb. in. units, and the conductivities in the reciprocal ohm (or mho), cb. cm. or cb in. units. The reference numbers designate the origin of the data, which is given below the table. It will be noticed that the resistivities of molten iron and steel are, roughly, about ten times that of the solid metal at ordinary temperatures; also that molten iron appears to have a resistivity of the order of, and approximately equal to, that of mercury at ordinary temperatures. It will also be noticed that more reliable information concerning these constants is badly needed, as this data is of great importance in the proper calculation of electric furnaces for steel and iron.

Philadelphia, Pa. Carl Hering.

Electric Pig-Iron Plant in Sweden.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—Believing that the starting of an electric pig-iron plant in Sweden is an interesting pioneer undertaking I send you a few data concerning this new undertaking. As your journal has already noted this new development, the following details will prove interesting:

A new company, "Trollhättans elektriska järnverk (The Electric Iron Company of Trollhättan), has recently been organized in Stockholm for electric smelting of iron ore for pig-iron production on a commercial scale. The methods to be employed are those worked out by Aktiebolaget Elektrometall in Ludvika, Sweden. The new plant is to be erected at Trollhättan, where the Swedish Government owns a large hydro-electric power station, from which electric energy is sold at cheap rates to surrounding cities and industrial consumers. The falls amount to about 75,000 hp, but will in future, after regulation of the Lake Venern, give 150,000 hp.

The first installation is to consist of three iron-ore reduction furnaces of 2500 hp each, of which one furnace is to be in reserve. The yearly production is calculated at 15,000 metric tons of pig iron, or 7500 tons for each furnace. Electric power will be bought from the Government at the rate of $7.46 per hp-year for the first 10 years and at $10 per hp-year for the following 10 years. A preliminary contract for renting up to 10,000 electrical hp has been drawn up.

The pig iron produced is intended to be used only for foundry purposes and to contain 0.4—1.0 per cent of phosphorus. Phosphorus-carrying ore from the Grängesberg mining district will be used. For the reduction of the ore German coke will be used from the Westphalia district, costing at Trollhätten $5.60, which is considerably cheaper than the Swedish charcoal ordinarily employed in Swedish blast furnaces.

The pig iron is calculated to be produced at $13.65 per ton.

The cost of the erection of the new plant is calculated as follows:

Three smelting furnaces, 2500 hp each	$40,000
Ladles, ladle-cars and various appliances	4,000
Crushing plant for crushing 35,000 tons of ore and 7000 tons of coke annually	2,400
Electric transformer and motors for crushing plant, transportation, lighting	1,600
Machinery for conveying ore and coke from harbor to crushing plant and from there to top of furnaces	4,000
Machinery for conveying pig iron and slag, and tracking	3,200
Buildings for furnaces and coke storage	16,000
Building for crushers	1,100
Excavation, grading, fencing and harbor	4,000
Office and laboratory	5,500
Superintendence and incidentals	9,100
Royalty	6,700
Total	$97,600

Ousby, Sweden. H. Hullegård.

International Congress of Applied Chemistry in London.

(*From Special Correspondents.*)

The London congress has turned out a brilliant success. The next congress will be held in 1912, in the United States, with Dr. Nichols as president and Dr. Morley honorary president—certainly a good combination. The official United States delegates were elected a provisional organizing committee with power to add to their number. There is lots of work in store.

As I said, the London congress was a brilliant, a very brilliant success which I shall never forget. I would have liked to send you a description of the main features, but we have been so much engaged for a week in a maelstrom of festivities, functions, receptions and lectures that there is no time left to sleep nor to think. And there are many who think that in spite of the high value of many of the papers presented, the chief value and importance of the congress must be found in the personal intercourse between the members from different countries.

Yet the most enjoyable part of my trip has been and will

SIR WILLIAM RAMSAY.

remain our little party on the S.S. *Kroonland*. About 40 in all, chemists with their wives or daughters, or with their bachelorship. For once we poor chemists owned a ship—captain, steward, brass band and all—and never was there a heartier jollity, no horseplay, just boyish, cheerful wit. The most exuberant ones were the boys over 60, like Wiley, Clarke, and Elliot.

During the whole trip there was not the slightest trace of anything but happy, cheerful, kind feelings. Only once in a while saw we pass silently a shade—one of the six odd fellow passengers who were not chemists:

"If you ain't a chemist,
You needn't come 'round.
The only men that I could see
Were those who dealt in chemistree."

My only regret was that so many good fellows, dear friends, fellow chemists, were not among us and thus missed the never-to-be-forgotten floating chemical steamship.

In London social entertainments were provided by our English friends on a most lavish scale. It is impossible to state all functions that were noteworthy. I only mention the reception at the Foreign Office, the conversazione at the University of London and Imperial Institutes, and the visit to Windsor. . . .

And yet how great, how powerful, how healthy our own dear country is, becomes more apparent to anyone who will look on this mosaic from abroad, and is not further influenced by small irksome details which once in a while make us forget its magnificent ensemble. The finest canvas of a Van Dyck examined under the magnifying glass would only appear as a rather mixed-up, unesthetic agglomeration of paint strokes.

Every trip to Europe makes us love our own country still better, though we would be fools not to recognize what is really great and beautiful in the older culture of Europe. And in returning from Europe, we take with us the memory of innumerable little acts of gracious kindness shown us lavishly by our cousins beyond the sea. A very hard task will be before us in 1912 when we must endeavor to return Europe's hospitality with equal grace and success. X. Y. Z.

* * *

The seventh International Congress of Applied Chemistry was solemnly opened by the vice-patron, the Prince of Wales, on Thursday, May 27. The congress met under the patronage of the king; the Prince of Wales was vice-patron; Sir Henry Roscoe, honorary president; Sir William Ramsay, president, and Mr. William McNab, honorary general secretary.

In his opening address the Prince of Wales emphasized that the rule of thumb is dead and the rule of science has taken its place. Sir Henry Roscoe thanked the prince, and Sir William Ramsay welcomed the members of the congress in four different languages. Dr. Harvey W. Wiley, of Washington; Prof. Armand Gautier, of Paris; Prof. Otto N. Witt, of Berlin; Prof. Paterno, of Rome, and Prof. Svante Arrhenious, of Stockholm, replied for the different countries.

At the concluding session, Sir William Ramsay announced that over 3000 members and over 600 ladies had assembled.

There were almost 1000 papers presented before the 11 different sections. Section X (Electrochemistry) was the most crowded, and discussion was almost impossible on account of the large number of papers. This must be avoided in the future by subdividing this section.

It is clearly impossible to give even a brief summary of the whole program. We will dwell only briefly on some papers of general interest.

* * *

National and International Conservation of Water Power.

Mr. Edward R. Taylor, of Penn Yan, N. Y., one of the presidents of Section X, and chairman of the conservation committee of the American Electrochemical Society, presented a very interesting lecture on this subject.

Mr. Taylor quoted from a report of the recent joint conservation conference in Washington. "The annual stream flow—by which is meant the volume of water annually passing into the sea—is approximately 70,000,000,000,000 cu. ft. for continental United States. Of this less than 1 per cent is restrained and utilized for municipal and community supply and related purposes; less than 2 per cent (or about 10 per cent of that in the arid and semi-arid regions) is used for irrigation; about 5 per cent is currently used for navigation, and less than 5 per cent is utilized for the production of power. From 85 to 95 per cent of the total volume of water is wasted in floods." . . .

"The amount available at a cost comparable to that of steam installation is estimated at 37,000,000 hp; this 37,000,000 hp exceeds our entire mechanical power now in use, and would operate every mill, drive every spindle, propel every train and boat, and light every city, town and village in the country. The direct yearly damage by floods since 1900 has increased steadily from $45,000,000 to $238,000,000; the indirect loss through depreciation of property is still greater; while the largest loss is that arising from the impediment to navigation and terminal transfers.

"We should adopt at once a broad plan of waterways improvement to all the uses of the waters and the benefits to be derived from their control, including the clarification of the water and the abatement of the floods, for the benefit of navigation, the extension of irrigation, the development and application of power, the prevention of soil wash, the purification of streams for water supply, and the drainage and utilization

the waters of swamp and overflow lands. Rough estimates of the cost of such practical improvement place the figure at $50,000,000 annually, the conclusion being reached that the work could be done in 10 years.

"If this work were to be done at the cost of the people the additional tax burden would be 62½ cents per year per capita, or $6.25 in all. Estimates of the total benefits resulting from such improvements place the figure at one billion dollars, or $12.50 per capita annually; that is, 20 times the cost."

As an illustration of what can be done, but as a typical illustration, Mr Taylor referred to "a little brook that one can step across. With a dam made in a simple way by stones from the surrounding fields a canal leads the water to the little shop where 25 hp of water is developed.

"Once there were 89 sawmills on that stream. Now there is

EDWARD R. TAYLOR.

but that single water-power development. Suppose each one could develop this 25 hp, and all was fed into one system, that would mean 2225 hp from that single little brook, with the impounding and conservation of a large quantity of water, and the saving of the equivalent of 30,000 tons of coal per year, worth at $2.50 per ton, $75,000 per year. A nice showing for a little brook, isn't it? But it is wasted, and as an engineer, W. P. Lay, of Alabama, would say equal to 30,000 tons of coal per year falling to waste over a precipice. . . .

"When you come to the rivers such little brooks feed, you may have power in large units for the largest manufactures and the most extensive industries.

"Private capital cannot do these great things as they should be done, for it cannot command capital at low rates of interest, and it is as important in this work to conserve capital as to conserve water. After some great object lessons have been developed by the State, private capital will be less timid. Some large developments privately made have been financially so disastrous as to thoroughly discourage private initiative, as note the early history of the large New England water powers, and later at Massena, N. Y., which failed in that it made provision for the development of the power, but made no provision for its utilization and was at the mercy of the highest bidder for its power and so fell into the hands of the latter.

"On the other hand, the nation can command cheap capital by its standard credit; can put the excess power of its early development to crushing stone, etc., for building roads and for other public utilities, and stand without strain the transition till more valuable markets for power are developed."

Mr. Taylor referred to the possibilities of the Susquehanna River and emphasized "the importance of each stream being comprehensively developed as a single interest, the unit system being the only real solution of the great problem of forestry, water conservation, navigation, and power. And conservation should extend to every farm brook in the hill country. . . .

"The foresting of hills and the impounding of flood waters is not only the solution of the flood and erosion question, but may be made immensely profitable as well if undertaken with adequate capital and good business sense. But no extravagant prices can be paid for land and water rights required and all concerned must work for the common good.

"Forestry can greatly supplement, but cannot replace impounding reservoirs for the storage of water and the regulation of stream flow. Keeping trees forever in their natural state, leaving them to mature, to die and fall and decay is only a travesty on conservation, and is not worthy of the consideration of an enlightened people."

With large rivers, especially in Europe, the question becomes international, "and if undertaken in the magnitude and importance the subject deserves, it would solve the everlasting peace of all Europe. It ought to be incorporated into international law that the nation that should destroy the conservation works of another should be compelled to pay a penalty equal to five or 10 times the damage done. Babylon is what it is to-day largely because of the destruction of its irrigating system in times of war."

Finally, Mr. Taylor paid a tribute to electrochemistry as a user of power. Twenty years ago electrochemistry as a user of power was unknown, but at this time it is one of the large and constant users of power, in decomposition by wet methods, in chemical manufacture, and electric smelting. The wet methods were first to start, and have made constant and rapid advances. Electric smelting is advancing by rapid strides, and it is predicted, by some most competent to judge, that the electric smelting of iron is already so promising as to make certain the use of enormous quantities of power for these uses alone.

Mr. Taylor's lecture was listened to with greatest interest and at the end it was proposed that a special day should be set aside or a special section organized to discuss these matters at the next congress.

Electric Furnaces.

Mr. F. A. J. FitzGerald, at Niagara Falls, N. Y., read a synopsis of all the papers on the use of the **electric furnace in the iron and steel industry** presented at the recent Niagara Falls meeting of the American Electrochemical Society and reviewed at length in our last issue. He also read a paper on the Lash process. There were also presented several papers by Keller and Gin relating to this subject.

A paper by Mr. Rudolf Taussig discussed large electric furnaces, especially for the **carbide industry.** According to Dr. A. Helfenstein, the maximum load for a compact electrode bundle in continuous operation is 2500 kw to 3000 kw, or 30,000 amp to 40,000 amp, as 75 volts to 90 volts, for a three-phase furnace; this means a total load of 7500 kw to 9000 kw, or 10,000 hp to 12,000 hp in the furnace.

With calcium carbide this development has been pushed even further in the construction of double three-phase furnaces, in which six (instead of three) electrode bundles, that is, two separate three-phase units, are placed in the same channel.

The above figures represent at present the practical limit on account of the very high temperature which necessitates special protective devices for the workingmen and the current-carrying cables, etc. There is further trouble due to smoke, and considerable difficulty in carrying out the charging operation.

It becomes of steadily increasing importance to utilize fully the calorific value of the furnace gases. In order to catch the gases with their high CO content it is necessary to build the furnaces gas-tight. The gas-tight construction of some recent designs of Dr. Helfenstein were explained by Mr. Taussig with the aid of illustrations.

Prof. S. A. Tucker's paper on the relative efficiencies of arc and resistance furnaces for calcium carbide manufacture covered the same ground as his recent American Electrochemical Society paper on this subject. (See our June issue, page 280.)

Caustic Soda and Chlorine.

Quite a number of interesting papers, though not all presented before Section X, related to this industry.

Dr. Leo Baekeland, Yonkers, N. Y., gave an account of three years' experience with the Townsend cell at Niagara Falls. This paper is printed in full elsewhere in this issue.

Messrs. F. J. Donnan and R. Finlay discussed the electrolysis of brine with the Finlay cell, which was described in and illustrated in our last issue, page 247.

The influence of electrolysis on the alkali industry was the subject of a paper presented by Prof. B. Lepsius, director of the Chemische Fabrik Griesheim-Elektron. The paper covered much the same ground as the speaker's lecture abstracted in our May issue, page 189, dealing especially with the electron diaphragm process and comparing it with mercury cathode and gravity processes.

"Passing to a review of the general position of the alkali industry, Professor Lepsius pointed out that the ammonia soda process of Solvay (1857, introduced into England by Ludwig Mond) had severely shaken the paramount position of the old Leblanc process, as supplemented by Deacon and Weldon, which was so strong because so remarkably cyclic. The weakness of the ammonia-soda process was that the chlorine which Le Blanc gained as hydrochloric acid was converted into calcium chloride—of little value. Hence, the chances of the electrolytic processes; the electrolytic chlorine is utilized in organic and inorganic chemistry, and the hydrogen which was first allowed to escape, now serves for welding and for filling balloons; 60,000 cu. m of hydrogen are gained every day at Bitterfield, and partly compressed to 150 atmospheres. About 33,000 hp are utilized in different countries in working Griesheim-Elektron cells to yield 40,000 tons of caustic soda and 45,000 tons of chlorine; one-third of the caustic alkali production of the world is prepared by the Griesheim process; the other electrolytic processes supply together about one-sixth, and the hundred years' giant, the Le Blanc process will succumb. These figures will probably be questioned." (London *Engineering*, June 4.)

Information on the Castner-Kellner process was given in Section V in a paper by Rudolf Taussig. The old Castner-Kellner cell had been rocked; the current strength had been limited to 500 amp, and mercury had been oxidized.

The second type of cell is the more interesting. The three compartments (chlorine now in the middle) are connected by syphons, and compressed air forces the mercury into the lateral compartments. The anodes, grids of platinum netting, 2 in. square, weighing 1 gram each, and fixed in little mercury cups of glass, are contained in diaphragm boxes of cement, each cell contains six boxes with 88 nets each, and the 528 electrodes take 4000 amp.

The cathodes are cast-iron grids. The iron shunt in the cathode compartment, which is now common property, is required because in the impoverished solution mercury ions would take part in the conduction and be oxidized if the decomposition of the amalgam were not rapid.

In the Kellner-Solvay cell (used in Belgium and elsewhere) the mercury is circulated over an overflow with the aid of a wheel; the current strength can be raised to 10,000 amp, and even 15,000 amp. In the most recent Kellner type this wheel had been replaced by an Archimedean screw, without securing any advantage, however.

* * *

A paper by Mr. G. Koller dealt with the **utilization of electrolytic chlorine.** Large quantities of electrolytic chlorine are produced by many of the more recent electrochemical processes. In many cases a remunerative commercial outlet has been found for this with some difficulty, and various proposals have been suggested for its utilization.

"Of these, one of the most feasible is the production of solvent liquids formed by allowing the gas to react chemically with acetylene. In this manner two allied processes benefited. At the present time practically all anhydrous materials used for extracting oil, fats, resins, and similar substances are inflammable, and many are highly explosive. Elaborate precautions are necessary therefore to prevent dangerous outbreaks of fire. Many restrictions are imposed by authorities, transportation companies, and insurance companies, which make it impossible in some cases to work many industries on anything like a profitable scale.

"The chief feature of these **chlorine compounds of acetylene** is that they are non-combustible and non-explosive solvents with a wide range of boiling points. Their use ensures absolute safety and combines the advantages of lower freight rates with a total absence of vexatious restrictions. This subject was received with great interest. In the discussion that followed it was objected that all these chlorine compounds are more or less narcotic in their action on animal life. This is perfectly true, but the property under discussion is not a very active one, and the danger arising therefrom is not as great as that from the average patent medicine." (London *Electrical Review*, June 4.)

* * *

The use of chlorine for **detinning tin scrap** was discussed in a paper by Mr. Elmer A. Sperry, of New York. The paper gives numerous practical considerations that have been developed in the practice of chlorine detinning. It has to do with the preparatory treatment of the scrap prior to the reaction period. This consists in billeting the scrap under peculiar conditions; practicable densities and the reasons found for the operations are clearly stated throughout. It also has to deal with the drying of the scrap and clarification thereof prior to detinning.

In connection with the reaction step proper, there are discussed a number of practical considerations which have forced themselves upon the operator, especially under the conditions of treating large quantities, such as opening up the interstices of the scrap for greater penetration of the reagent; also means which have been found for considerably increasing the depth and penetration of the chlorine, resulting in a higher percentage of purity of the resulting black scrap and a definite lowering of the residuary tin content therein.

A discussion is given of the various means of accomplishing this, such as centrifugal stress and varying the temperature of the scrap. The phenomena of the sudden rise of temperature is also treated and the correct temperatures stated, and means for equalizing and controlling these temperatures to bring about the most rapid performance of the process.

Under the heading of treatment of the resulting black scrap, the discussion is taken up under the heads of removal of the tin chlorides, the removal of the iron chlorides, and also a simple electrolytic treatment which has been found effective in removing the last traces of the acid radical, and thereby creating a true alkaline and perfect weathering scrap.

Further, the question is discussed of the subsequent treatment of the tin chloride in purifying and preparing it for the market, also methods of handling, storing and transporting same.

Another paper by Mr. Elmer A. Sperry discussed new uses to which refrigeration has been put in connection with liquefaction of gaseous chlorine; also the processes that have been found in practice to successfully cope with the problem of liquefaction of dilute chlorine, where the dilution consists of both foreign gases and moisture and where the amount of diluent present is considerably in excess of that admissible in the liquefaction process heretofore practised. The paper also deals with means of denuding foreign gases and air of such chlorine content as they may possess prior to the ejection of such gases from the plant to the outer atmosphere.

Fixation of Atmospheric Nitrogen.

Hofrat Prof. A. Bernthsen, of the Badische Anilin und Soda Fabrik, presented an interesting lecture, with experi-

metal[illegible]action, on the new **process of the Badische Company**, invented by Dr. Schoenherr, which was described in [illegible] and illustrated in our last issue, page 245. For the description of the electric furnace process itself, the reader must be referred to our former description, as Professor Bernthsen's paper contains nothing new. We, therefore, abstract only those parts of the paper which deal with the chemical methods of working up the nitrogen oxide-air mixture into marketable products.

The absorption at Notodden is at present carried out according to the "acid" process; the first product is dilute nitric acid, which is subsequently converted into calcium nitrate. The apparatus necessary is very extensive, on account both of the small contents of nitrogen oxide in the gases, and also of the very large volume of the gases treated.

The hot gases, on leaving the electric furnace, are first made to pass through boilers, thereby giving up some of their heat, and creating the supply of steam used for heating the vacuum pans, in which the solutions of calcium nitrate are evaporated. These vacuum pans can be heated directly by the furnace gases if desired, or by the intermediate agency of steam.

These gases are then still further cooled and afterward passed into a large empty tower or other receiver, in which time and opportunity are given for the nitric oxide to be oxidized to nitrogen tetroxide. If the gases contain 2 per cent of nitric oxide, 12 seconds are required for the oxidation of 50 per cent of it, while the oxidation of 90 per cent requires 100 seconds. The gases are then passed into very large granite towers, about 65 ft. high, and filled with lumps of quartz, and in these towers the acid absorption is effected by means of water, or of the dilute nitric acid which is collected at the bottom of the tower In order to recover the oxides of nitrogen which remain unabsorbed, the gases are finally treated with milk of lime or soda, and give rise either to a mixture of nitrite and nitrate or to pure nitrite.

The more dilute the gases are, the more difficult is the absorption, and consequently the greater concentration of the gases is obtained by the process of the Badische Anilin und Soda Fabrik constitutes a not unimportant advantage over Birkeland and Eyde's process. It is stated that the gases leaving the Schoenherr furnace contain about 2 per cent of nitric oxide, that is, they are from one and a half times to nearly twice as concentrated as the Birkeland and Eyde process.

More recent experiments at the Badische Anilin und Soda Fabrik have shown the possibility of effecting the absorption directly with milk of lime, and in this case, the "acid" absorption could be dispensed with, and the absorbing towers and the initial outlay on the plant considerably reduced.

The calcium nitrate obtained by any of these operations can, without further treatment, replace Chili saltpeter for purposes of agriculture, and is in some cases even better. Even a mixture of calcium nitrate with nitrite and free lime appears to have no harmful effect. Such operations as these require abundant and cheap water power

Considerable quantities of air saltpeter will shortly be put on the market and probably, within a few years, the annual output on the market will reach 100,000 tons.

* * *

A paper by Mr. S. Eyde, one of the inventors of the **Birkeland-Eyde process**, should also be noticed in this connection, although it was presented before the Royal Society in London and not before the congress. We reproduce here those parts of Mr Eyde's paper which deal specially with the working up of the gas mixture into nitrates.

The temperature of the Birkeland-Eyde flame exceeds 3000° C., or perhaps 3500° C The temperature of the escaping gases may vary between 800 and 1000° during ordinary working. The furnaces are made of cast steel or iron, the middle of the furnace being built out to a circular flame chamber. The electrodes are led radially into this flame chamber. By aid of centrifugal fans, the air is brought into each furnace through tubes from the basement.

When the air in the flame chamber has been treated by the electric flames the nitrous gases formed pass out through a channel built along the casing of the furnace and thence out through the lower part of the furnace to two fireproof gas-collecting pipes, about 2 m in diameter, which convey the gas through the basement out to the steam-boiler house.

In the boiler house, the gas passes through four steam boilers, in which the temperature, which was, as mentioned, 1000° C., is reduced. The heat given off by the gas is used for concentrating the products, and in the winter time for warming the factory buildings. The steam produced in the boilers is utilized in the further treatment of the products. In the boiler house there are also two large and two small air compressors, which supply compressed air for pumping acids and lye in the factory's various chemical departments.

The gases pass on from the steam boilers through an iron pipe into the cooling house with the object of completing the cooling commenced in the steam boilers. This cooling is necessary in order to obtain a suitable absorption. Each cooler consists of a number of aluminium tubes, over which cold water runs, while the hot gases pass through them. The temperature of the gas is considerably reduced. From the cooling chambers the gases go on to the oxidation tanks.

These oxidation tanks are vertical iron cylinders lined with acid-proof stone. The object is to give the cooled gases a sufficient period of repose, in which the oxidation of the oxide of nitrogen may have time to take place. The necessary amount of oxygen is present in ample quantity in the air which accompanies the gases from the furnaces.

From the oxidation tanks the gases are led into the absorption towers. All the towers are filled with broken quartz, which is neither affected by nitrous gas nor by nitric acid. To assist the passage of the gases on their way from the furnaces there are centrifugal fans constructed of aluminium on each row of towers.

The gases enter at the base of the first tower, go up through the quartz packing, and thence a large earthenware pipe, enter the top of another tower, through which they pass downward through the quartz to the bottom of the third tower, and so on until the air, relieved of all nitrous gases, leaves the last tower. Water trickles through the granite towers, and this is gradually converted into a weak nitric acid, while the liquid used in the wooden towers is a solution of soda.

The absorbing liquid enters the top of the tower and is distributed in jets by a series of earthenware pipes, so that the permeating gases come in immediate contact with the absorbing liquid. In the granite towers nitric acid is thus formed and in the wooden towers a solution of nitrate of soda.

The liquid emerges in a constant, even stream from the bottom of the towers, that from the granite towers running into a granite cistern. Hence it flows into the montejus, which serve to pump up the acid, which has to pass repeatedly through the tower before it has become strong enough for the purpose for which it is intended. The "montejus" are of stoneware strengthened with iron shields; are worked by compressed air, and send the acid up into large stoneware jars.

From these jars the acid again runs through the towers as described. The montejus work automatically. The wooden towers are percolated, as already mentioned, by a solution of soda, otherwise the whole process is practically similar to that in the granite towers.

The solution of soda, owing to its far greater power of absorption, effects the separation of the last remains of nitrogenous gases from the accompanying air. Of the entire quantity of nitrous gases passed through the absorption system about 97 per cent is absorbed.

The finished nitric acid coming from the towers, which has a strength of about 30 per cent by volume, is collected in granite cisterns, from which it is drawn to what is called the "dissolu-

tion works." These consist of granite vats filled with limestone, over which the acid is poured. This drives off, with violent effervescence, the carbonic acid contained in the limestone while the nitric acid takes its place and forms a solution of nitrate of lime or calcium nitrate in water. This solution is now pumped into vacuum evaporating apparatus. The object of boiling in vacuum is the well known fact that great saving is thereby effected in the heat required.

The steam required for the evaporation is obtained from the steam boilers, heated, as before mentioned, by furnace gases. The concentration of the nitrate solution in the evaporizing plant is continued until the specific weight of the liquid at a given temperature shows a content of 13 per cent of nitrogen.

This solution is then sufficiently evaporated, and can be pumped up into the solidification chambers. These are fitted with shallow iron pans, under which cold air is pumped to accelerate cooling. After some time the nitrate stiffens into a brittle, crystalline mass, hard as stone. This is broken up into lumps and is taken into the crushing machines. These consist of ball mills, which reduce the mass to a granular state. The coarse powder so produced is raised by elevator to a vat, from the bottom of which it is tapped into casks holding 100 kg, net weight.

The barrels are made at the company's own cooper shops and are lined with paper to guard against damp. The color of the product depends on the limestone used in the manufacture. The nitrate of lime is used in various chemical works, as well as for manure, the only difference being that, for the former purpose, the product is not ground fine, but is run direct in the liquid state into thin iron drums in which it stiffens into a solid mass.

As to the further treatment of the nitrate formed in the alkaline towers, when this is pumped away from the towers and water, also some nitrate of soda and bicarbonate.

The further process is designed to separate the pure nitrate from the other substances. This is accomplished by first boiling away some of the water, which is done, as in the case of the nitrate solution, by steam from the steam boilers, heated by the furnace gases. The nitrite solution, concentrated to a suitable boiling state, is run into crystallization pans, in which the crystallization of the nitrite takes place.

The crystals are separated by centrifugal means and are conveyed by a screw transporter to a drying apparatus, where they are subjected to a current of hot air. The finished product is then run into casks containing 300 kg each. This nitrite of soda is used as the raw material in the manufacture of certain kinds of aniline colors. The manufacture of nitrite is carried on in a special building.

In the entire process of manufacture, both of nitrite and nitrate, no coal is used; all the machinery is worked by electric power, and for heating and evaporating the nitrate and nitrite solutions, the only steam employed is that obtained by the hot gases passing through a system of steam boilers.

Moreover, this industry is not confined to the two products hitherto mentioned—nitrate of lime and nitrite of soda—but there are possibilities for the development of a whole series of new industries, of which Mr. Eyde specially named the production of nitric acid and nitrate of ammonia, nitrate of potassium, and others. They have succeeded, in conjunction with the Nobel (nitroglycerine, etc.) Syndicate, in concentrating their weak acids by means of gases from their furnaces to acids of high percentage, which can be transported.

In a paper presented before the congress by Prof. BIRKELAND, the other inventor of the **Birkeland-Eyde process**, some further interesting details were given. They are now building 1600-kw furnaces instead of the 800-kw units, of which 35 are run at Notodden, eight in series; the air enters the flame disk through a number of perforations arranged in circles on radial lines in the furnace walls. The 1600-kw flame disk has a diameter of 2 m and a thickness of about 10 cm. Currents of 500 amp are starting from points on the tubular copper electrodes not more than 1 mm in diameter, and those partial arcs which are constantly spreading out and breaking off are not steady for more than 0.00001 second.

* * *

The **calcium cyanamide** industry was discussed in a paper by Dr. NIKODEMUS CARO, of Berlin, on "The Nitrolim Industry and Allied Industries." Since we have discussed many times in the past the production of calcium cyanamide or nitroline from calcium carbide and nitrogen, only a few new interesting details from Dr. Caro's paper shall be abstracted here from London *Engineering*, June 4.

He first referred to the influence of the impurities contained in the carbide—features of considerable industrial importance. Ordinary calcium carbide contains lime, sulphides, phosphides, carbon and other impurities, and their presence and physical properties influence the absorption of nitrogen so much that carbide of the same composition, but made in different types of furnaces, may behave very differently in the nitrolime furnace.

The second raw material of the process, the nitrogen, should not contain any other gases or water. Linde apparatus supplies a suitable nitrogen; but as they are somewhat expensive, the older process of binding the oxygen of the air by means of copper, which is burned to oxide leaving the nitrogen, is also applied; the copper is afterward reduced again.

Dr. Caro made an interesting announcement in this connection. He has succeeded in isolating nitrogen from the combustion gases of producer gas. He conducts these gases through a mixture of copper and copper oxide, which absorbs oxygen and carbon monoxides, and thus obtained a mixture of nitrogen and carbon dioxide, the latter is absorbed by alkali carbonate solution, which binds the CO_2 more readily if the oxygen and other gases have previously been removed.

The nitrogen has to be free from water, and also from CO and CO_2, because these gases react with calcium carbide with liberation of carbon; they also destroy the cyanamide already formed (the cyanamide formation being a reversible process $-CaC_2 + N_2 = CaCN_2 + C$).

With a carbide of 82.3 per cent of CaC_2 (calcium carbide) and 14.7 per cent of CaO (lime) the temperature above which the already formed cyanamide is decomposed into nitrogen and carbide again is 1360° C.; in the presence of more carbide decomposition begins at lower temperatures.

Owing to this reversibility the process of carbide and nitrolim manufacture cannot be made continuous; the cooling carbide becomes impervious to nitrogen, and has hence to be ground up and reheated for absorbing the nitrogen. Now, although the combination of CaC_2 and N takes place with the evolution of heat, that heat is not sufficient to continue the process when cold nitrogen and cold carbide are fed into the furnaces, the more so as the specific heat of carbide increases from 0.243 at 0° C. to 0.288 at 1200° C. The furnaces have hence to be heated; but if the heat were applied from outside, the temperature would rise too high on the walls and decompose the formed cyanamide. The heating is, therefore, effected in the mass itself in heat-insulated furnaces by means of electrically heated rods of carbon; after a while the heating can be interrupted, and will proceed automatically, all the more readily the purer the carbide.

For this reason the above-mentioned additions to the carbide are undesirable as ballast to be heated. The total amount of electric energy is small, being only 3 hp-years per ton of nitrogen bound as cyanamide. A factory commanding 12,000 hp can produce 20,000 tons of nitrogen lime per year, corresponding in nitrogen contents to 20,000 tons of ammonium sulphate and 25,800 tons of Chili saltpeter. Large works are, hence, rising, mostly relying on water power; those at Knapsack and Westeregeln burn lignite, however.

Some other abstracts of congress papers will be found in the Synopsis of Current Literature in this issue. All members of the congress will receive the complete *Transactions* in due course.

Calculations in Ore Concentration.

An interesting paper, of marked originality, was recently presented by Dr. Rudolf Gahl, electrochemist and metallurgist of Morenci, Ariz., before the Colorado Section of the Western Association of Technical Chemists and Metallurgists. In this paper Dr Gahl discusses simple mathematical calculations as a means of getting as much useful and practical information as possible from screen tests and assays in ore concentration. The paper is published in full in the April issue of the organ of the association, the *Western Chemist and Metallurgist*. In the following the paper is reprinted almost in full.

The size of American concentrating plants, especially of those treating copper ore, has very greatly increased in recent years. When we consider the enormous sums of money represented by the ore treated in these plants and how great might be the financial loss due to slight errors in mill operation, the necessity of keeping close watch on the work becomes apparent.

It is not possible to so thoroughly control a plant of this kind as it is to regulate, say, an electrical central station, where a number of ammeters and voltmeters will indicate precisely the operation of the plant. The best indicators which the concentrating man has at his command are screen tests and assays, but a great deal also depends on his ability to interpret properly the readings of these indicators. To do this successfully requires the application of some mathematics.

Assays.

Dr. Gahl first discusses what information can be obtained from assays of heads, concentrates, and tails, regarding the saving which a concentrator is making.

Let one ton of ore be put into the mill, and let y and z (fractions of one ton) be the respective weights of concentrates and tails produced from 1 ton of ore. The assays of ore, concentrates and tails may be designated as a, b, c, respectively. For instance, a concentrator operating on 3 per cent copper ore may produce concentrates carrying 17 per cent Cu and tails with 0.7 per cent Cu. In this case we have $a = 0.03$, $b = 0.17$, $c = 0.007$.

Then the two facts, that the weight of ore equals the combined weights of concentrates and tails, and that the amount of copper or other valuable constituents in the ore equals the combined amount of copper in concentrates and tails, are expressed by the two equations:

$$1 = y + z \qquad (1)$$

$$a = by + cz \qquad (2)$$

If z is eliminated from these equations we get,

$$y = \frac{a - c}{b - c} \qquad (3)$$

Now y is the weight of concentrates produced from 1 ton of ore. We will get the saving by dividing the amount of copper in the concentrates (by) by the amount of copper in the 1 ton of ore (a) so that the saving S is

$$S = \frac{by}{a}$$

Substituting this deduced value of y in equation (3) we get the following equation for the saving.

$$S = \frac{b\,(a - c)}{a\,(b - c)} \qquad (4)$$

This formula contains no weights and it is clear, therefore, that the saving of a concentrating plant may be calculated from the assays of the ore, concentrates, and tails, without knowing anything about the quantities used or obtained.

For example, for the numerical example noted above this formula gives $S = 0.8$; or, in words, the saving of the concentrating plant is 80 per cent.

In plants where ore and concentrates are weighed (the weight of the tailings being taken by difference) the results of this formula can be checked against the saving calculated by other methods. There are three more possibilities, which in our terms are as follows:

$$S = \frac{by}{ax} = \frac{\text{copper in concentrates}}{\text{copper in ore}} \qquad (5)$$

$$S = \frac{by}{by + cz} = \frac{\text{copper in concentrates}}{\text{copper in concentrates and tails}} \qquad (6)$$

$$S = \frac{ax - cz}{ax} = \frac{\text{copper in ore minus copper in tails}}{\text{copper in ore}} \qquad (7)$$

If the weights and assays are all correct, these four methods should check. In practice, of course, they do not check exactly. An example of the results obtained by the four methods in a certain copper concentrator, for several consecutive months, is as follows:

Method of calculation.			Saving.
(1) Assays only	77.48	78.59	80.33
(2) Weights and assays of ore and concentrates	78.09	80.73	79.00
(3) Weights and assays of tails and concentrates	77.64	79.11	80.02
(4) Weights and assays of ore and tails	77.52	78.69	80.27

These four methods of calculation are not independent of each other. If the amount of copper in the ore as calculated from weights and assays equals exactly the amount of copper in concentrates and tails as calculated from their weights and assays, all four methods will give the same results; but if there is a discrepancy, the methods will give discordant results. In the latter case it will depend entirely on specific conditions which method is the most trustworthy, whether, for example, one sample is more reliable than another, or whether the weights can be relied upon, etc.

In the derivation of the formula for the saving calculated from assays only, equation (3) was quickly passed over, but it has special interest:

$$y = \frac{a - c}{b - c}$$

Since y means that fraction of the ore which makes up the concentrates, it is equivalent to what is spoken of as the "rate of concentration." For instance, in our previous example of an ore carrying 3 per cent copper, and giving concentrates carrying 17 per cent of tailings of 0.7 per cent copper, we would find for y the value of 0.141, or expressed as a common fraction $\frac{1}{7.09}$. This is equivalent to the statement that 7.09 tons of ore have produced 1 ton of concentrates, or that the ore has been concentrated 7.09 into one.

This equation is also interesting from another standpoint. The rate of concentration is expressed by the assays of the ore, concentrates, and tails; but in deriving this equation we made no assumption as to the kind of assays which it represents. Therefore, it will evidently hold true for copper, gold or silver assays, or for any other set of chemical determinations. All of these determinations cannot, of course, be made with equal exactness, and when we have a practical problem of determining the rate of concentration from a set of assays, such determination will be chosen as are most reliable.

On the other hand, the fact that the rate of concentration can be calculated in so many ways, permits us to eliminate y and compare the different assays directly. If, for example, a, b, c, represent assays for gold; a_2, b_2, c_2, assays for sulphur, and a_3, b_3, c_3, assays for iron or any other constituent in ore, concentrates, and tails, respectively, the relations will hold true thus:

$$\frac{a - c}{b - c} = \frac{a_2 - c_2}{b_2 - c_2} = \frac{a_3 - c_3}{b_3 - c_3} \text{ etc.} \qquad (5)$$

Dr. Gahl remarked that he had not at hand any assays to show the application of this equation, but it is clear that it will allow the calculation of a complete analysis of the tailings if a complete analysis of the ore and concentrates and only one assay of the tails be given.

Screen Tests.

What is the additional information which can be obtained from screen tests?

Take, for example, a problem of this kind: A certain concentrator disposes of its tailings in the following manner: After classification in cone classifiers, the spigot discharge contains the coarse sand with a little water, and is used to build a dam across the mouth of a gulch adjoining the tailings end of the plant. The overflow is conducted into the basin thus formed, where the suspended solid matter settles, liberating clear water, which is again used in concentrating. The question arises: what percentage of the tailings goes to the dam and what percentage to the pond? This problem can easily be solved by making some sizing tests on the general tails and the two products of classification mentioned.

Let the total quantity of the tailings be 1 ton, that part going to the dam be y, and the portion going to the pond be z. Then we have the equation,

$$1 = y + z \qquad (6)$$

If we screen the samples of each material on, say, a 100-mesh screen, we will have a certain fraction of each sample remaining on the screen, which we will call α_{100}, β_{100}, γ_{100}. If we screen a general tails sample we will evidently get the same percentage of 100-mesh material as if we split this sample into the part which builds the dam and the part which feeds the pond, screened these two samples separately and combined the corresponding sizes. This fact is expressed by the equation,

$$\alpha_{100} = \beta_{100} y + \gamma_{100} z \qquad (7)$$

or by elimination of z from (6) and (7)

$$y = \frac{\alpha_{100} - \gamma_{100}}{\beta_{100} - \gamma_{100}} \qquad (8)$$

This equation naturally holds true for any other screen size and if we screened on a 200-mesh screen we would have,

$$y = \frac{\alpha_{200} - \gamma_{200}}{\beta_{200} - \gamma_{200}} \qquad (8)$$

The screen to be used in a given case depends, of course, on the material to be screened, the principal point to be observed being the screen which will give the most exact results. It is to be understood that screening does not give absolutely exact results, for no screen is absolutely uniform; but those who have made wet-screen tests often enough to become proficient will admit that screening on fine sizes, say, from 100-mesh down, is fairly accurate. Although the error in screening expressed in percentage may be greater than the error in assaying, there are cases in which the results based on screen tests are much more reliable.

In the case under consideration the screen tests were as follows:

	General tails.	Tails to dam.	Tails to pond.
Percentage on 100-mesh	44.4	75.2	3.1

Substituting the screen results on 100-mesh screen in our formula we find that 57.3 per cent went to the dam and the balance of 46.7 per cent to the pond.

This problem could have been solved from the assays only. The same set of examples used for the screen test was assayed with the following results:

	Cu per cent.
General tails	0.85
Tails to dam	0.72
Tails to pond	1.16

Our formula (3) will solve this problem. Although we have deduced this formula for relations existing between ore, concentrates, and tails, it holds for any case in which one product is split into two other products, or where two different products are combined into one. Dr. Gahl emphasizes the fact that the two products into which one is split, or which are combined into one, must be different, for if they are the same the problem cannot be solved, and if they are nearly alike, the error in the result will be great. Therefore, if there is but little difference in the assays of the products, screening will give better results, but if the material is of practically the same size the assays should be the basis of the calculations.

Returning now to the dam problem, let a represent the assay of the general tails, b the assay of the coarse tails, and c the assay of the fine tails; y will represent the fraction of the tails going to the dam. Using these assays in the formula we get $y = 70.5$ per cent.

This is decidedly different from the figure 57.3 per cent which we obtained from the screen tests, and is evidently not reliable. This is due to the fact that the differences between the assays of the three products are so small that they are not a safe basis of calculation. This then is a case where screen tests give much more reliable results than assays.

That the assays are really conformable with the screen tests can be shown by calculating the assay of the general tails from the assays of the coarse tails (dam) and the fine tails (pond), making use of the proportion between the two found by screening. The calculated general tails assay, according to this, would be,

$$a = bx + cy$$

$$a = 0.91 \text{ per cent Cu.}$$

This checks the actual assay within the limits of the ordinary cyanide assay for copper, and shows that the results by assaying have not contradicted the results obtained by screening.

But we are able to solve this problem in still another way, by considering the percentage of water carried by each one of the materials in question. We have the equation for the dry pulp,

$$a = b + c \qquad (9)$$

If we call the weights of the wet pulps A, B, and C, respectively, the following equation is also true,

$$A = B + C \qquad (10)$$

If α, β, γ, represent the percentages of solid matter in A, B, and C, respectively, we will have the following equations,

$$a = A\alpha \qquad (11)$$

$$b = B\beta \qquad (12)$$

$$c = C\gamma \qquad (13)$$

Substituting these values in equation (10) it follows:

$$\frac{a}{\alpha} = \frac{b}{\beta} \times \frac{c}{\gamma} \qquad (14)$$

Since it is again unessential what quantities we consider, we will make $a = 1$. Then

$$1 = b + c \quad \ldots \quad c = 1 - b \qquad (15)$$

$$\frac{1}{\alpha} = \frac{b}{\beta} \times \frac{c}{\gamma} \qquad (16)$$

By eliminating c from the two equations we get,

$$b = \frac{\beta(\alpha - \gamma)}{\alpha(\beta - \gamma)} \qquad (17)$$

The moisture samples taken gave the following results:

$\alpha = 13.1$ per cent solids.
$\beta = 42.5$ " " "
$\gamma = 6.9$ " " "

By substituting these figures in our equation we find

$$y = 56.5 \text{ per cent}$$

which represents the percentage of dry tailings that would go to the dam. This checks the results which we obtained from the screen tests, which was 57.3 per cent.

It seldom happens, however, that problems in the distribution of pulp are as easy as this one. If three products are combined into one, or one is split into three, the calculations are more complicated. For example, a concentrator produces three final tailings products, by the following treatment: the coarsest ore is treated on Wilfley tables, the next finer on one set of vanners, and the finest set on still another group of

vanners. The tailings from all three sets of machines are combined into general tails. The question arises: what percentage of the general tails originates from the Wilfley tables, and what percentage from each set of vanners? This question could be solved by screening the different tails samples. Let us call

a_{30} the fraction of general tails remaining on 30-mesh screen,
b_{30} the fraction of Wilfley tails remaining on 30-mesh screen.
c_{30} the fraction of first vanner tails remaining on 30-mesh screen.
d_{30} the fraction of second vanner tails remaining of 30-mesh screen.
a_{200} the fraction of general tails remaining on 200-mesh screen, passing 30-mesh.
b_{200} the fraction of Wilfley tails on 200-mesh screen, passing 30-mesh.
c_{200} the fraction of first vanner tails on 200-mesh, passing 30-mesh.
d_{200} the fraction of second vanner tails on 200-mesh screen, passing 30-mesh.
β the fraction of Wilfley tails in general tails.
γ the fraction of first vanner tails in general tails.
δ the fraction of second vanner tails in general tails.

Actual screening showed that only a portion of the general and Wilfley tails remained on the 30-mesh screen, and the vanner tails contained only negligible portions of such material. This furnishes the equation,

$$\beta b_{30} = a_{30}$$

from which β can be calculated.

For the screenings passing through 30-mesh and remaining on 200-mesh, the following equation will hold true,

$$\beta b_{200} + \gamma c_{200} + \delta d_{200} = a_{200}$$

But according to our assumption,

$$\beta + \gamma + \delta = 1$$

and by eliminating δ we get

$$\gamma = \frac{a_{200} - d_{200} - \beta\,(b_{200} - d_{200})}{c_{200} - d_{200}}$$

The actual screen tests for one day were as follows:

$a_{30} = 17.7$ $\quad$ $a_{200} = 36.8$
$b_{30} = 40.7$ $\quad$ $b_{200} = 53.9$
$\quad$ $\quad$ $c_{200} = 44.0$
$\quad$ $\quad$ $d_{200} = 9.3$

The calculation gives the following results:

$\beta = 43.5$ per cent
$\gamma = 23.3$ " "
$\beta b_{200} + \gamma c_{200} + \delta d_{200} = a_{200}$
$\beta + \gamma + \delta = 1$

The elimination of γ furnishes the equation,

$$\delta = \frac{a_{200} - c_{200} - \beta\,(b_{200} - c_{200})}{d_{200} - c_{200}}$$

$\delta = 23.3$ per cent.

As a check on this calculation $\beta + \gamma + \delta$ may be formed which should add up to 100 per cent.

This may be sufficient to show how similar problems may be solved. If it is necessary frequently to determine what percentage of the total tails originate from the different machines in a concentrator it may be wise to install mechanical appliances for this purpose. At Dr. Gahl's suggestion the Detroit Copper Company has done this in the following way: The tail launders from the different groups of machines are conducted separately to the bottom of the mill. There separate sample slots are provided for the discharge of each launder. These slots are of equal width and are operated by the same mechanism, consequently the samples cut out by them are proportional to the total amount of tailings. It may be mentioned, by the way, that the three stream of tails are combined after passing their respective sampling slots and that a sample of this general tails product is taken through a slot which is operated by the same mechanism that actuates the three sampling devices mentioned above.

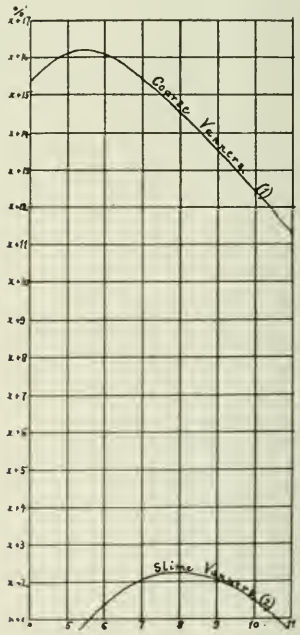
Of course, the assay of the general tails can be calculated from the weights and assays of the three separate tailings samples. The comparison between the calculated and assayed general tailings sample furnishes a check on the work of sampling and assaying.

Distribution of Pulp.

The question may be asked whether it is of so great importance to know how the pulp is being distributed in a mill, and whether the mill man cannot tell from the appearance of his machines whether the distribution is correct. On the basis of a comparison between actual determinations and estimates from appearance of the machines, Dr. Gahl concludes that such estimates are in no way trustworthy.

There is one distribution of pulp which will give the minimum loss and the only question is whether the results obtained by that distribution are sufficiently better than any others to warrant exact determination of the proper conditions.

This is illustrated by Dr. Gahl by reference to a practical



CURVES OF COMMERCIAL SAVING.

case. In a certain concentrating plant two vanner feeds are made. The separation of the two feeds is made in a V-shaped box classifier, in which, however, no hydraulic water is used, so that only a rough classification is made, throwing the greater part of the sand and the smaller part of the slime to the first set and the rest of the sand and the bulk of the slime to the second. The question now arises: how much feed should each set of vanners carry?

Some tests showed that if the best possible saving of copper was desired, only a very small feed should be carried per machine, and that increasing this load increased the loss of metal. But such a policy could not be carried out in a commercial plant as the question of operating cost would enter. An extremely light load would be impossible, for only a relatively small profit would remain after deducting operating

costs, which in the case of a small load would form a serious item.

Dr. Gahl calls "metallurgical saving" the percentage of valuable metal recovered. By deducting from this figure as many per cent as would pay for the operation of the machine, he gets what he calls "commercial saving." Now, the commercial saving if the best, or expressed mathematically, has a maximum, for a greater load. Assuming, for example, a copper value of 15 cents per pound, curves 1 and 2 in the accompanying drawing will represent commercial saving for the coarser vanner feed and the fine vanner feed, the maximum being at 5½ and 8 tons, respectively.

This would mean that the feed should be distributed between the first and second sets of vanners in the proportion of 11 to 16 in order to get the most economical load, and shows the value of a method in guiding the concentrator foreman in the distribution of pulp. In arriving at this conclusion the assumption has, of course, been made that by changing the size of the classifier spigot discharge, the character of the two feeds is not changed. This assumption will always be safe when the existing distribution is not very different from the one found best by the method.

The result indicated, viz., that a vanner treating a coarse feed should receive a smaller load than a vanner treating a slime feed, may seem surprising in view of the fact that a slime table should receive a very small load in order to make a good saving. Dr. Gahl thinks also the fact that a slime vanner carrying its best load will make high tailings and a vanner treating coarse material will produce low tailings, would induce some mill managers to take the feed away from the slime machines and increase the load on the coarse.

Nevertheless, considered from the standpoint of the curves, this would be a mistake. The explanation is that this slime feed contains such a large percentage of what has been called absolute slime, on which concentrating machines cannot effect a saving by any means, that the proportion of copper that can be saved is very small, and would not pay for the operation of the large number of machines necessary to save it. A coarser feed, however, contains only a small percentage of this extremely fine slime, and for this reason the recovery will be high in every case. But even though it may be high already, it may pay to try to increase it by distributing the pulp over more machines.

There is one point that Dr. Gahl emphasizes in this connection: that the tailings assay gives no information regarding the work which a machine or plant is doing. The only criterion is: do the tailings contain values in a form that can be saved by wet concentration? It is not easy to determine this point, and the only place where this determination is attempted appears to be in the concentrator of the Green Cananea Company, Canannea, Mexico. Although the methods in use for this purpose may not be perfect, it would seem that only by adopting some such plan shall it become possible to distinguish between avoidable and unavoidable losses and learn to eliminate the former.

The Calcium Carbide and Cyanamide Works at Odda, Norway.

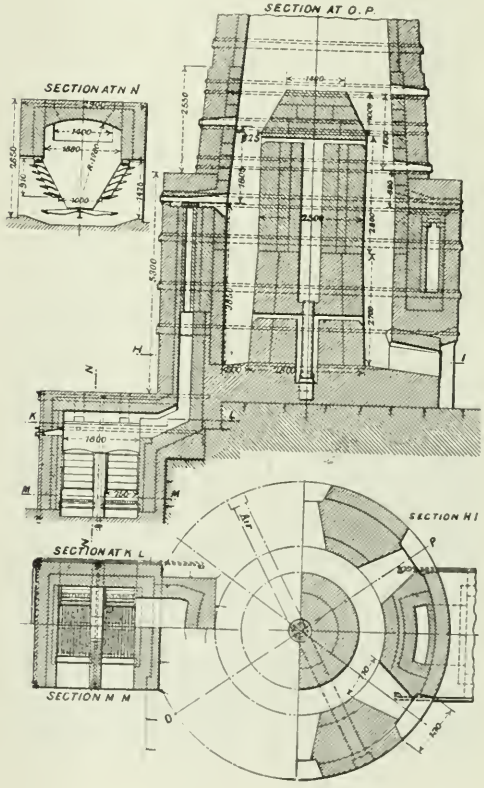
In our May issue (pp. 212 to 216) a description was given of the general arrangement of the new hydro-electric plant, with calcium carbide and calcium cyanamide works, at Odda, Norway. In the following we give some further details of these works, especially of the carbide and cyanamide works. This article is abstracted from the exceedingly full description which is now being published in serial form in London *Engineering*. The accompanying illustrations are also reproduced from our London contemporary (April 23, May 7 and 28).

Carbide Works.

Besides the methods of transportation and handling of materials, the arrangement of the lime kilns and carbide furnaces is of chief interest.

Lime Kilns.—Each of the five kilns has a capacity of 30 tons, and four of them suffice to supply the calcined lime required for the whole of the 12 electric furnaces, so that one of the kilns is a stand-by. Provision has been made for erecting a second row of kilns parallel to those already in use, to correspond with a duplication of the electric furnace plant, when this is required by the market.

Sections are given of one of the kilns with its gas producers in Figs. 1 to 3. These producers are constructed of brickwork with firebrick lining, and for each of the lime kilns there are four producers, two on each side of the kiln, and each has a



FIGS. 1, 2 AND 3.—DETAILS OF LIME KILNS.

door at each end, making eight doors. The firebars are of cast iron and are constructed as shown in the section, Fig. 3. The bars in two parts, that near the fire is flat, with slight declination toward the fire, while that on the outer side is in the form of a V-channel. Water is fed into the top channel and overflows into the others, and this supplies sufficient vapor

The coal is charged from the floor level of the kiln house. The kilns are built at 15 m (49 ft. 2.5 in.) centers, and rise to a total height of 24 m (78 ft. 9 in.).

At the top an archway has been formed, 5 ft. 6 in. wide, the products of combustion passing on each side of the archway. The chimney top, which is 3 ft. in diameter, has a cap pivoted on an iron standard, so that by means of a wire extending to the ground level the kiln may be completely closed down.

The limestone wagons for charging the kilns pass through the archway, their contents being tipped into the limekiln

through a hopper fitted with a valve. The level of this charging platform is 14 m (45 ft 11 in.) from the bottom of the kiln. The diameter of the kiln at the lowest part is 7.1 m (23 ft. 3½ in.), while the inside diameter is 3.150 m (10 ft. 4 in.). The walls are 750 mm (2 ft 5½ in.) thick.

In the center, as shown in Figs. 1 and 2, there is a brick core with a conical top, leaving a combustion chamber in the form of a ring for the burning of the limestone. In the brick core there is a central passage which is utilized for the passage of air to mix with the gas for combustion.

The uptake for the gases from the producers is rectangular in plan (Figs. 1 and 2) and communicates through a flue in the outer walls of the limekiln with a circular passage around the walls, having 18 small inlets to the interior of the limekiln. These inlets or cavities extend right through the outer wall and are fitted on the outside with manholes, so that, if necessary, firebricks may be inserted for the regulation of the area of opening for the inflow of gas from the vertical flue. The air

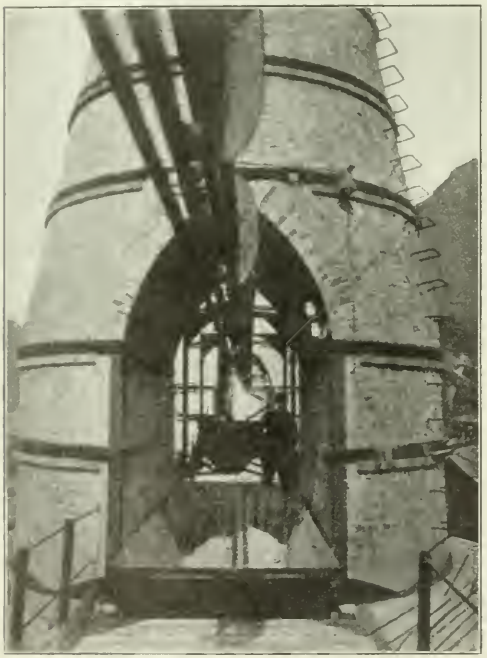


Fig. 4.—Charging the Lime Kiln.

supply to assist combustion within the kiln is admitted, as already indicated, through a vertical passage in the brick core at the top of which small horizontal ducts pass the air to the combustion chamber.

These air ducts are above the level of the cavities admitting the producer gas. Thus the ascending gas meets a current of air at the top of the ring chamber of the kiln, and at the point past which the limestone falls from the main upper chamber at the top of the kiln into the ring chamber. The point of admixture of gas and air is about 4 m (13 ft. 1½ in.) from the floor of the ring chamber, so that the burned lime is cooled before it reaches the discharge door of this chamber.

Transportation of Materials.—The calcined lime is withdrawn into wagons running on a telpher railway and fitted with 2 hp electric motors. The calcined limestone is taken by these wagons to a crushing mill adjoining the carbide electric furnace house. The lime is discharged into hoppers, which feed, through transporting bands, the jaw crushers employed for breaking the lime.

The coal from the anthracite silo is conveyed by wagons traveling on a telpher railway, and is discharged into hoppers which feed, through band conveyors, electrically operated jaw crushers to break it into very small cubes for use along with the lime in electric furnaces. In addition to jaw breakers, there are "centrifugal mills" similar to those used for grinding cement.

From these the anthracite or lime is conveyed and elevated for discharge into storage hoppers, and from these the material is drawn as required into an electrical automatic weighing machine, having two compartments. Although the hoppers are of considerable capacity, the discharge spouts are brought close together, and the feature of the ingenious electric appliance is that it is arranged to weigh out the two constituents of the electric furnace charge in their correct proportions, so that there is absolute precision in this respect—a point of considerable importance in ensuring satisfactory results in the production of calcium carbide.

Calcium Carbide Plant.—In the furnace house there are 12 electric furnaces, each of 1400-kw capacity, constructed on the Alby system. "The high degree of efficiency now realized by these furnaces is the outcome of much research, and for obvious reasons" sectional drawings are not given. The voltage is 50, and the current 28,000 amp.

The transformers used are placed in underground chambers under the furnace so as to ensure the minimum length of conductor. The conductors from the switchboard are laid in a tunnel of large area under the ground level, and very powerful fans are fitted near to the transformers. These take their current of air from the tunnels, so that the temperature of the transformers is comparatively low.

The furnaces are charged by hand from adjacent hoppers, replenished from bunkers traveling round the building, from the automatic weighing machine. The furnace charging is practically continuous, and the men are screened from the exceedingly high temperature of 3000° C. (5720° Fahr.) by gauze curtains.

The furnaces are tapped at intervals of about 45 minutes and their capacity is from 7 to 8 tons per day of 24 hours. The carbide is teemed into receptacles (heavy cast-iron trays) 1 m square, which ahe conveyed by electric traversers to the carbide-cooling house, immediately adjoining the furnace house.

The cooling house is 15 m (49 ft.) wide by 27.4 m (90 ft.) long. The cooling frames are built up of iron plates with rails at 12 in. centers, on which the carbide slabs are deposited. The frames are set on a gradient of about 20° from the side walls down to the center of the building, where there is a conveyor traversing the building, and on to this the slab gravitates.

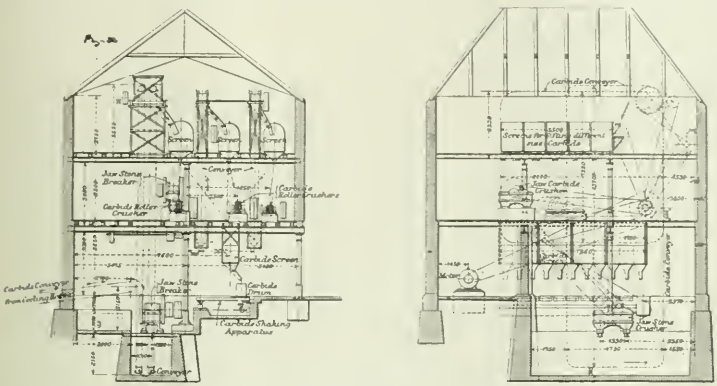
The carbide slab is 6 in. thick, and is almost red-hot when deposited. Openings are left in the wall of the building, and a constant current of air passes over and under the cooling plates, which are perforated at frequent intervals. During the process of cooling the slab of carbide cracks, owing to contraction, and after it has lain for about eight hours the workmen find it easy to break the pieces up, and assist them to glide down the slope, where they fall on to the transporter band, built up of plates and angles, and operated by a 10-hp electric motor.

The band is not continuous for the whole length of the building, but is arranged to deliver the material at both ends of the cooling house, that at one end being intended for the adjacent cyanamide works, where the carbide is converted into calcium cyanamide. At the other end of the building the calcium carbide is delivered for transference by band conveyor to the crushing house, to be reduced to cubes varying in size according to market requirements.

Carbide Crushing and Grinding Plant.—The whole of the system of breakers and conveyors is operated by one 40-hp motor. The carbide is conveyed from the cooling house and deposited into the first two jaw stone breakers on the ground

level (Figs. 5 and 6), where it is broken into cubes of about 4 in. in size.

This crusher discharges the material into a series of small buckets mounted on a wheel which rotates at a rate corresponding to the travel to the conveyor buckets under it, and this the material is fed to the conveyor without any being lost. The conveyor works in combination with an elevator and thus the



CARBIDE CRUSHING PLANT.

cubes are raised to the top floor and fed through a hopper into a screening machine of the rotary type.

The perforation is of five different meshes, in order that the material may be separated and deposited into five hoppers, according to the size (Fig. 6). The tailings exceeding 80 mm (3.15 in.) fall over the end of the revolving screen and pass to a second jaw stone crusher. This latter is on the intermediate floor (Fig. 6) and deposits the material crushed in the same way as in the instance already described, into a conveyor and elevator, which discharges into a second cylindrical screen on the top floor, where again the material is separated into several sections of varying size.

The tailings over 25 mm (1 in.) pass to a roller crusher on the intermediate floor, and thence by conveyor and elevator to the third of the cylindrical screens, where the material is again separated into five divisions, by means of the screens and hoppers under them, the range being from 1 mm to 15 mm (0.04 in. to 0.59 in.).

Thus the three cylindrical sifting screens have each five receiving hoppers, as shown in Fig. 6, and from each there are independent shoots to the series of hoppers. The carbide of each size is delivered on the packing floor (Fig. 6) without being passed through successive screening and crushing machines to reduce it to the minimum sizes.

By the mesh of the respective sieves, the material is divided into marketable sizes. These are 2 mm, 2 mm to 4 mm, 4 mm to 7 mm, 8 mm to 15 mm, 15 mm to 25 mm, 25 mm to 50 mm, and 50 mm to 80 mm, or ranging from 0.08 in. to 3.15 in. The finished-material hoppers are all of the same size or cubical capacity, but there are two hoppers for the material of the two largest sizes.

The shoots of these hoppers are fitted with a sliding shoe, which can be opened when the terne-plate drums are placed under them. The drums for the reception of the material are placed on an oscillating platform (Fig. 5), which is pivoted at one end, while under the other—under the drum—there is a projection in contact with an eccentric wheel, which when rotated gives the platform a shaking motion. This ensures that the greatest volume of material shall occupy the minimum of space in the drum. It has thus been possible to arrange that the cubical capacity of the drum is only slightly in excess of the volume of carbide for a given weight

The manufacture of the drums, and of the barrels in which these are encased, is, of itself, an interesting department of the Odda works, as labor-economizing machinery has been introduced with striking results.

The drums are made of terne plates and are of two sizes: to take 100 kg (220 lb.) or 50 kg (110 lb.) of carbide, the diameters being respectively 425 mm (16.73 in.) and 300 mm (11.81 in.), while the height in both instances is 600 mm (23.62 in.). Five hundred of the 100-kg drums are manufactured per day of 10 hours, there being employed 11 boys under 18 years of age, with a foreman, and the total labor-cost is 80 kr., equivalent to 22 cents per drum. For further details of the department for the manufacture of the drums and barrels the reader must be referred to the descriptions in London *Engineering*, May 7.

Cyanamide Works.

Ten thousand tons of the calcium carbide annually manufactured at the Odda works are utilized in the adjacent cyanamide factory belonging to the North-Western Cyanamide Company, Limited, for the production of this new fertilizer, which contains 20 per cent of nitrogen and upward. The trade name which has been adopted for calcium cyanamide is nitrolime.

Concerning the production of calcium cyanamide much has been published before in this journal: see, for instance, our Vol. I, p. 423; Vol. IV, pp. 136, 327, and especially the paper by Erlwein in our Vol. V, p. 77. The process used at the Odda works is that of Frank and Caro, which starts with calcium carbide and nitrogen as raw materials, the principal reaction being $CaC_2 + N_2 = CaCN_2 + C$.

The process is controlled by the Societa Generale per la Cianamide in Rome, Italy, by whom manufacturing licenses are granted. The British concessionnaires are the North-Western Cyanamide Company, who own the rights for Scandinavia, 30 per cent of Germany, Belgium and all the British colonies excepting Canada. Their works are at Odda, and the plant is typical of the most modern practice in order to secure the economic production of a uniform product containing 20 per cent of nitrogen.

The Odda works are the largest in operation, although others of equal, or even slightly greater, capacity are now being constructed. The following list gives the works in operation, with their annual producing capacity, and those (in the second column) now under construction and contemplated

Works completed	Tons.	Works under construction.	Tons.
Odda	12,000	Dalmatia (two factories)	8,000
Briancon	3,750	Italy (two factories)	7,000
Martigny	3,750	Bavaria	12,500
Piano d'Orte	5,000	Niagara	5,000
Bromberg	2,500	Osaka	4,000
Westergein	5,000	Contemplated in India, South Africa and Canada	12,000
Knapsack	5,000		

The manufacture involves problems in chemistry and in mechanical engineering. It requires the liquefaction of air and the separation of the oxygen and nitrogen respectively therefrom. The furnaces in which the calcium carbide combines with the nitrogen are of considerable electrical interest (although not a very high temperature is required), and the arrangement both for grinding the material to a fine powder and for the handling thereof from stage to stage in the process of manufacture are of mechanical interest, because a high degree of economy has been attained as in the case of the carbide factory already described.

Apart from the important work of obtaining the nitrogen from the air, the chief desideratum in the process is to ensure that no air comes in contact within the carbide during its 30 to 40 hours' treatment in the furnace, as the oxygen in the air would increase the proportion of carbonate of lime at the expense of the cyanamide and reduce the percentage of nitrogen.

One element conducive to economy is that the process is endothermic, the absorption of nitrogen by the carbide generating a large proportion of the heat necessary to effect the combination, so that the 190 electric furnaces in use, each producing 1 ton of nitrolim per week and operated at 60 volts to 75 volts, requires comparatively little electrical energy to maintain the temperature at from 800° C. to 1003° C. (1470° Fahr. to 1830° Fahr.). Care has also to be exercised in order to ensure the uniform distribution of the temperature throughout the furnaces.

The preparation of the calcium carbide for the absorption of the nitrogen in the electric furnaces includes the grinding of the carbide to a powder before it is charged into the furnaces. The carbide is first conveyed by an aerial ropeway from the cooling house at the carbide works to the building where the grinding machine is erected. It is then passed into hoppers, to which the retorts are brought by an overhead crane to be filled under a shoot, and then conveyed and placed in the furnaces.

The nitrogen is applied in the electric retorts, and at the end of 30 to 40 hours these are taken out of the furnaces and conveyed to a cooling platform where the cyanamide is removed. It has then the form of cakes, of great hardness, not unlike coke. Subsequently, this cyanamide, or nitrolime, is ground to a fine powder and is subsequently stored in silos having a capacity of from 6000 to 8000 tons. It is taken thence by automatic machinery, packed into double bags having an inner lining of paper to exclude any moisture, which would be detrimental to the nitrolime.

Liquid Air Plant for Production of Nitrogen.—Attention may now be directed to the plant for obtaining the nitrogen from the air. This has been constructed by the Linde Eismaschinen Gesellschaft, Munich, Germany. The process is the invention of Professor Linde. It is based on the fact that at atmospheric pressure, nitrogen boils at —196° C.; liquid air boiling at —194° C., and liquid oxygen at —183° C. By using the well-known rectification process followed in the manufacture of alcohol, the nitrogen can be completely separated from the oxygen.

The Linde company guarantees that the nitrogen does not contain more than 0.4 per cent oxygen, a percentage which has neither an unfavorable influence on the chemical reaction nor leads to the burning of the electrodes. The plant has been working for several months, and the guaranteed maximum has never been exceeded. It was cut down by the Linde company for a production of 375 cu. m (about 13,000 cu. ft.) per hour and is run by a 200-hp electric motor. All parts are in duplicate in order to prevent any long interruptions in the working, the second half of the plant acting as a stand-by.

The diagram, Fig. 7, shows how the separation of oxygen and nitrogen from the air takes place, and will better explain the process than would sections through the various apparatus. The right half of the diagram represents the part of the plant in actual working; the left half shows the part held as a stand-by. We shall deal only with the former part. Fig. 8 is a perspective view of the Linde house.

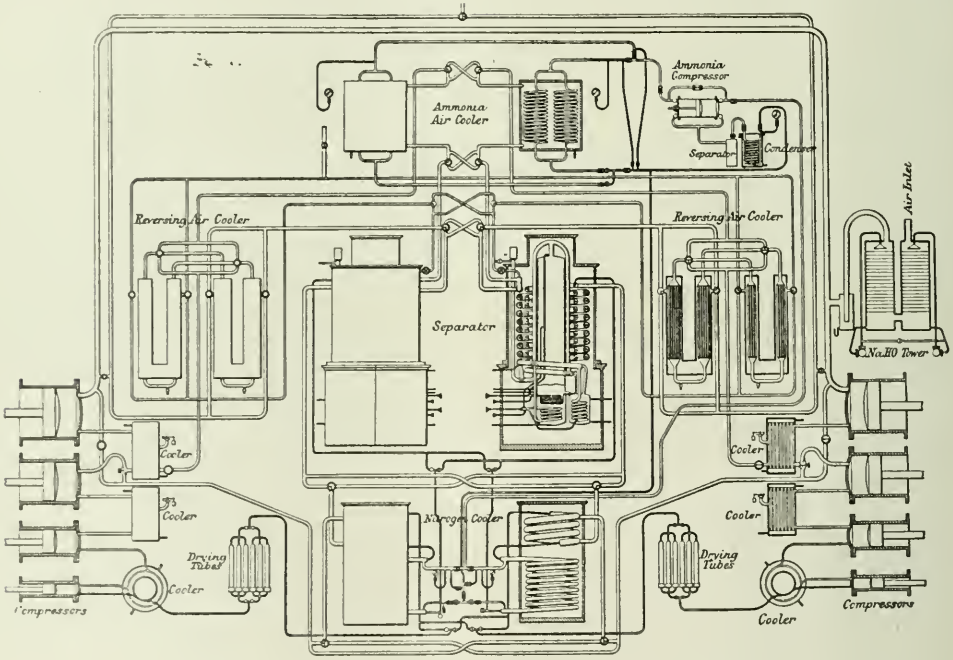


FIG. 7.—LINDE PLANT FOR SEPARATING NITROGEN AND OXYGEN FROM AIR.

The air to be treated is drawn from the atmosphere by the largest of the four cylinders of the compressors, and through two towers, through which a soda liquor is made to trickle, the object of this being to free the air as much as possible from carbonic acid.

The air is compressed to approximately 4 atmospheres (57 lb. per square inch). It is then cooled, first, in a water-tower down to the temperature of the cooling water, and, further, by being passed in pipes through a reversing air cooler. Around these pipes flow cold oxygen or nitrogen from other portions of the apparatus. The water condensed is drained off at the bottom.

In the rising leg of the apparatus ice is liable to form as the temperature is below freezing point. It is got rid of by periodically reversing the direction of the flow by the valves indicated.

The air next passes to an ammonia-cooler, where its temperature is further reduced to about —20° C. or —25° C. In this almost the whole of the remanent moisture is abstracted.

On leaving this almost absolutely pure and dry the air passes next to the separator or still, which it enters through a counter-current interchanger consisting of the usual system of concentric pipes. Flowing itself through the inner of these pipes, it is cooled by an oppositely flowing current of nitrogen or oxygen evaporating from the liquid state.

The incoming air thus passes from the interchanger at a very low temperature and being led next to a coil immersed in a tank of liquid oxygen liquefies there, since it is at a pressure of 4 atmospheres.

From this coil it expands through a throttle valve, with the result that a large proportion of it is obtained in the liquid state, and at about atmospheric pressure. The liquid thus produced is led to a point near the top of a rectifying column filled with glass marbles, over which it trickles to the bottom.

On its way down it meets with an ascending current of gas evaporating from liquid below. This gas is rich in oxygen, and this oxygen having a higher temperature of liquefaction than the liquid air it meets in the rectifier, is condensed by an equivalent proportion of nitrogen being distilled off from the descending liquid.

The latter therefore enters the tank at the bottom enriched in oxygen, while the gases passing off above are nearly pure nitrogen. To remove the remaining traces of oxygen the rectifying column is extended at the top above the point at which the liquid air is introduced.

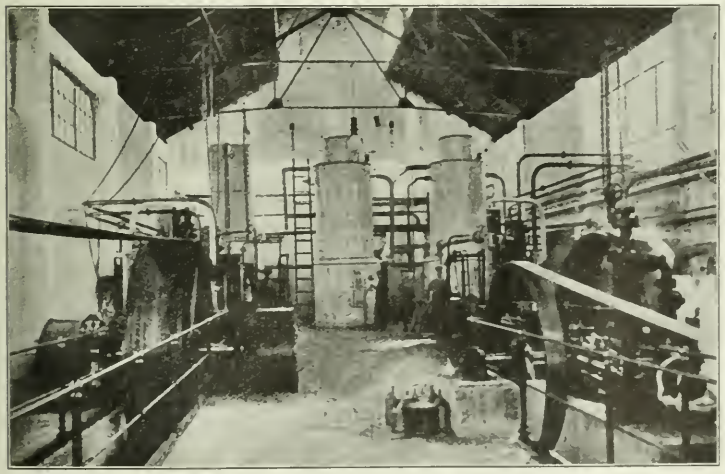


FIG. 8.—LINDE PLANT FOR OXYGEN AND NITROGEN FROM AIR.

The gases ascending through this extension meet a downward flow of pure liquid nitrogen which robs them completely of oxygen so that finally pure gaseous nitrogen alone escapes from the top of the column. Of the supply thus obtained the bulk is drawn through the interchanger to the electric furnaces, but a proportion goes to form the supply of pure liquid nitrogen needed in the upper part of the rectifying column.

To this end it is led into the second cylinder of the compressor, and thence, through intermediate coolers, to the other cylinders, from the last of which it is delivered at a pressure of 120 atmospheres.

After cooling and cleaning, the compressed gas is next passed through a coil in a tank of liquid oxygen derived from the separator. Here it condenses to the liquid state, and is finally passed through a throttle valve to the top of the rectifying column. By expansion through the valve the supply of liquid nitrogen at low pressure needed for rectification is obtained. The oxygen separated from the air is evaporated in a special receiver by a portion of compressed air, and is led by a special pipe to the counter-current spiral to cool the compressed air.

The evaporation of the ammonia in the coolers is governed by an ammonia compressor, which draws the ammonia vapors from the coolers and compresses them in a condenser in which they are precipitated for delivery afresh in a liquid state into the coolers.

As it is not possible to free the air in a large measure from moisture and carbonic acid before its entrance into the separator, the separator is gradually choked up. The working period lasts six to ten days. In order that no interruption should take place, the second half of the plant is started working a few hours before the first half is stopped, and when this is done the second half is already yielding nitrogen.

Three Years' Practice of the Townsend Cell.*

BY L. H. BAEKELAND, *Sc. D.*

In 1907 I have described the Townsend cell and its practical operation. (ELETROCHEMICAL AND METALLURGICAL INDUSTRY, June, 1907; *Jour. Soc'y Chem. Ind.*, Vol. 26, No. 13). I am able now to make a further report on this subject from data gathered during almost three years and a half of continuous operation of the Niagara plant, using about 1000 kw, and which is now rapidly being increased to a quadruple capacity.

The cell units as used orignally were designed for 2000 amp, but it was found afterward that by a slight alteration these same cells could be operated more advantageously at 2500 amp; since about a year, 76 cells have been thus run at this increased load. On the strength of our experience, all the new cells which are being installed will run at a minimum load of 5000 amp; they are designed so, that in case of necessity, they can be forced up to 6000 amp, and still run at good efficiency.

The first full-sized Townsend cells, as designed by Townsend and Sperry, which we had under observation in 1904, were run either alone or in series of three and under those conditions showed astonishingly high amp-hour and energy efficiencies. Under such conditions the amp-hour efficiencies were close to 100 per cent. But it makes a considerable difference whether an electrolytic cell be run alone, nursed by experts, or whether it be operated in large series and left in the hands of unskilled workmen.

In a series of, say, over 70 of such cells, it frequently happens that one single defective cell depresses considerably the average efficiency of the whole group; irregularities in the circulating electrolyte may often do considerable damage in the whole system and escape detection while doing much mischief. Furthermore, remedies cannot always be applied immediately, because it is often more expensive to stop a whole plant, which

*A paper read before the International Congress of Applied Chemistry in London.

[illegible] without the slightest interruption. These [illegible] considerations have frequently been over- [illegible] or inventors who had no opportunity of [illegible] face to face with purely commercial considera

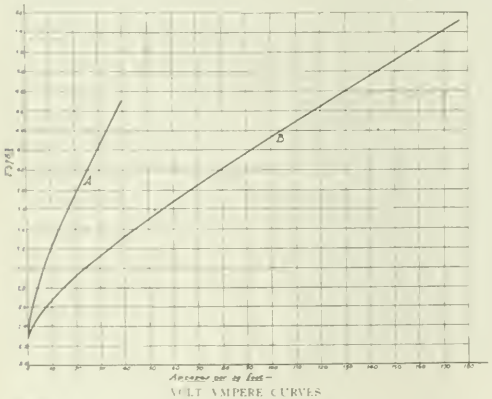
[illegible] experience alone can teach us the relative im- [illegible] these matters, and the cold-blooded bookkeep- [illegible] very often upset the most elaborate estimates of [illegible] engineer.

The latter naturally have a tendency to put great stress on the value of high efficiencies, and yet this factor, considered alone, is often very misleading. For instance, we soon found that it was much cheaper to sacrifice some power, and accept somewhat higher voltages, as to run the cells at a higher output and turn out more goods with the same size of plant and the same cost for the operating staff.

At one time it was thought advisable to run the Townsend cell at current densities not exceeding, say 100 amp per square foot of anode surface, which enabled us to operate at very low voltage and to show rejoicingly high energy efficiencies, and which kept the graphite anodes almost intact of corrosion; but later on the bookkeeping accounts convinced us that it was better business policy to run at about 1 amp per square inch, sacrifice some power and some graphite and yet show better financial results in the end.

In fact, close observation of all the facts connected with cell operation has enabled A. H. Hooker to elaborate a system of curves whereby we can now design Townsend cells of various sizes and output which can be operated at any desirable voltage and of which we can tell beforehand not only the value of output, amp-hour and energy efficiencies, but the cost of maintenance and even the number of days which will elapse between two successive cleanings of the diaphragm.

With all these factors at hand we have been able to decide which way of operating was cheapest in the end. For instance, we found that it was good practice to run the cells so as to clean the diaphragm once in about 30 days, although a slight



change in the way of operating enables us to considerably lengthen this period, but it was preferable to design the cell so as to make opening, examination and cleaning so easy and inexpensive that any cell which has to be thus treated remains out of active service only for a few minutes. Likewise, after we had decided that it was more advantageous to run at such high loads that the graphite anodes begin to be attacked, the latter were designed of compound construction, so as to make renewals very simple and to limit the attack to the surface blades, so that the graphite can be used over and over again until it is entirely consumed. So successfully has this been accomplished that a conspicuous part of many electrolytic plants, the cemetery of old anode parts, has entirely been done away with.

But if circumstances demand it, we shall have it within our power to change the operating of the cells so as to run at very low voltage and this at current densities which are still relatively large as compared to some other cells, and at the same time reduce the consumption of graphite to a very minimum. In places where power is very expensive, and skilled labor is cheap, it may prove advantageous to operate that way and construct the cells acordingly.

The accompanying curve B shows a record of the average voltage of a series of 76 cells, run at varying current densities, the latter being calculated per active surface of anodes. These voltages are decidedly higher than the initial voltages at which the cells are started.

The curve A shows a similar record for a well-known electrolytic cell, which I shall not name, and which has been in full commercial operation for a number of years.

It may be of interest to state that we found the use of aluminium conductors very advantageous, although at the time they were adopted considerable scepticism was expressed as to their value for a plant of this kind. The conductivity of aluminium is decidedly less than that of copper and, on account of this fact, bars of large section have to be used; notwithstanding this, the relation of price and specific gravity is such that there is a decided initial economy in the use of aluminium.

But the main advantage resides in the fact that someway or other aluminium has proved less liable to corrosion in an atmosphere where small amounts of chlorine are occasionally present. So little effect is there that even after years of continuous use the unvarnished or unpainted aluminium bars show a relatively bright surface. On the other hand, copper conductors under the same conditions become rapidly covered with a soft but thick crust of some basic chloride of copper which, on expanding, seems to favor further corrosion and disintegration.

Although the Townsend cell is commonly described as a diaphragm cell, I should point out that we may just as well consider it as a cell with a circulating electrolyte, somewhat on the order of the gravity cell, with that difference that here the cathode liquor is pressed through capillary channels and this insures rapid circulation in one sense and minimizes the possibility of diffusion.

By a very simple device, consisting of a glass tube which can be raised or lowered, the hydrostatic pressure in the anode compartment can be quickly adjusted so that the percolating liquid can be made to vary in flow and in strength. When we take into consideration the very large current densities at which the Townsend cell is run, it becomes a matter of course that the liquid should be pressed through the diaphragm at a rather abundant rate.

It has been found that the advantageous rate of percolation for 2500-amp cells is included in rather broad limits, say, from 15 liters to 30 liters per hour; the maximum rate of percolation giving the weakest caustic solution.

At one time it was though that in order to obtain advantageous amp-hour efficiencies it was necessary to make the percolation abundant enough so that the cathode liquid should not contain over 10 per cent of NaOH. Since then, experience has taught us that this is not strictly so. The 2,500-amp cells are run now at an average percolation of about 24 liters per hour, yet the caustic liquid contains an average of 150 grams of NaOH and about 200 grams of NaCl per liter of liquid.

But even this average corresponds to conditions which are not considered very favorable, and from what has been accomplished already we know that a cathode liquor of 20 per cent NaOH and an average amp-hour efficiency of 96 per cent is within possible reach, although thus far these results have not been obtained steadily for the full set of cells. We also know that the cathode liquor can be made as strong as 25 per cent NaOH, but this involves close watching and it is simpler to evaporate a somewhat weaker cathode liquor.

One of the remarkable conditions in the Townsend cell is

the almost entire absence of hypochlorites and chlorates in the anode liquor. This in itself is one of the symptoms of high efficiencies. The presence of these oxygen compounds in any electrolytic cell for the manufacture of caustic or chlorine indicates defective construction, or bad operation, or both. The formation of chlorates or hypochlorties is mainly due to recombination of the causticcation with the chlorine o fthe anode compartment.

It has been observed that whenever the Townsend cell begins to show low efficiencies, the anode liquor indicates relatively large amounts of chlorates and hypochlorites. For instance, if the average amp-hour efficiency falls to about 93 per cent, then the anode liquor shows as much as 0.6 gr. of the $NaClO_3$ and 0.1 of NaClO per liter. The presence of these undesirable compounds not only lowers general efficiencies, but hastens very considerably the graphite anode corrosion.

The caustic cathode liquor of the Townsend cell contains very little, if any, of these oxygen compounds, and this explains easily why, during the evaporation of these lyes, so little trouble is experienced, as far as concerns the corrosion of the metallic vessels, in which the evaporation occurs.

Our method of treating the cathode liquor can be described summarily as follows: The liquor, containing at least 14 per cent of NaOH, flows in a set of three vacuum pans run in multiple effect. When leaving the last pan most of the sodium chloride has already been eliminated and the clear, thick liquor now contains about 50 per cent NaOH; 0.8 per cent Na_2Co_3 and 2 per cent NaCl. This liquor is now further concentrated in open finishing kettles.

The finished product, as sold in drums, titres from 76 per cent to 77½ per cent New York and Liverpool test. It is of excellent white appearance and contains rather less than 2 per cent carbonate, and a small amount of NaCl, which it does not pay to eliminate further.

It is a known fact that whenever caustic lyes contain impurities, more especially when they contain hypochlorites or chlorates, a rapid corrosion of the heating tubes in the vacuum pans follows, as well as a rapid destruction of the cast-iron finishing kettle. This naturally involves, first of all, bothersome and expensive renewals of the tubes in vacuum pans, and the expense for this item has been brought down to an occasional small repair.

Furthermore, it has been found that our finishing kettles last an unusually long time. This factor of renewals of finishing kettles is usually a serious item of expense. After a certain number of tons of caustic have been finished in one single kettle, the latter gets in such a bad condition that it has to be sent back to the foundry and be sold as old iron. Some of our pots have thus far finished over 3000 tons, and are still in very good condition, and promise a much longer record. In one or two instances where pots had to be discarded, the damage was merely due to very careless firing and not to corrosion.

In direct relation with all this stands the other fact, that the finishing of Townsend caustic produces only a relatively small amount of so-called "bottoms." These "bottoms" are a variety of impure caustic which gradually accumulates in the kettles, and which contains all the impurities, mainly due to the effect of corrosion on the metallic vessels in which the evaporation is carried on. Such "bottoms" have to be sold at a loss, and oftentimes are a decided "drug on the market." Up till now, the rates of the quantity of "bottoms" to that of first-quality caustic soda which has been produced by the Niagara plant has averaged only one ton in 700 tons of finished caustic, and even this includes the results of the starting period, when the plant was not in proper running condition, and when our operating staff was considerably less skilled than now. But this much can be said as to the wear of finishing kettles and pans, that until now this item of expense averages less than 20 cts. per every ton of finished caustic, and there is every probability that in the future this cost will be considerably reduced.

The Preparation of Aluminium in the Laboratory.

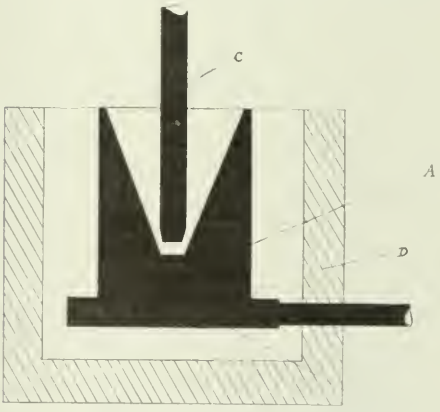
BY S. A. TUCKER.

Aluminium may be prepared in the laboratory on a small scale without difficulty and give an excellent illustration of the Hall process which is of value to the student of applied electrochemistry.

The method which I have found successful is to use a furnace as illustrated. This consists of a crucible *A* turned from a 5-in. diameter graphite rod resting on the graphite base *B*, which forms the negative pole of the circuit.

An adjustable vertical graphite electrode *C*, 1¼ in. diameter, is connected to the other pole through a variable resistance. The power circuit should be 110 volts, having a capacity of about 300 amp, and provided with a circuit-breaker and ammeter.

In order to conserve the heat as much as possible the crucible *A* is surrounded with any good heat-insulating material,



APPARATUS FOR ALUMINIUM PROCESS.

such as infusorial earth, sand or lime, which is retained by the brickwork *D*. The crucible can be made conical as shown so that a wide opening is maintained and but little charge used, or a cylindrical container can be used equally well.

The voltage is measured by inserting a voltmeter reading to 150 volts across the poles.

The process is started by lowering the vertical electrode until an arc is formed on the bottom of the crucible. As soon as the crucible is warmed somewhat, cryolite in lumps of about ½ in. diameter is added, allowing time for them to melt, adding in quantity sufficient to fill the crucible two-thirds full.

When perfectly fluid the volts will be about 80 and the current 30 amp, the vertical electrode being placed as near the bottom of the crucible as posible without arcing.

If the weight of the cryolite added has been noted, 15 per cent of purified alumina can then be added in small portions, and as soon as an appreciable quantity is taken into solution the volts will fall to from 10 to 12, the current rising to 225 amp. Bubbles of carbon monoxide will ascend from the anode by the inter-action of the oxygen and the graphite, showing that the process is going on correctly.

There are two causes which will interfere with the progress of the experiment in this way: first the anode is corroded quite rapidly, increasing the distance between anode and cathode, and, second, the decomposition of the alumina raises the resistance of the bath. Either cause tends to make the conditions revert to high voltage and low current.

When this does take place the electrode is lowered, and if this does not bring about the required change, a little more alumina is added to the bath, the aim being to maintain by these means a low voltage, high amperage, and an evolution of gas bubbles from the anode. Sometimes when the voltage suddenly rises a tap on the electrode holder of the vertical electrode will set things going again in the proper manner, apparently because the sudden shock dislodges a gas envelope around the anode.

The process should continue for an hour or an hour and a half in order to obtain an appreciable quantity of the metal, and is discontinued by withdrawing the vertical electrode and lifting the crucible with a pair of tongs while the contents is still molten and pouring into an iron mold. On cooling the aluminium is usually found in one button weighing from 20 to 30 grames.

It sometimes happens that too much alumina has been added which tends to make the charge very hot, accompanied by sputtering. This is corrected by the addition of more cryolite and allowing the process to proceed in the manner indicated.

A crust will probably form on the surface of the bath, but will do no harm provided that it is not allowed to congeal around the anode. This can easily be prevented by breaking into the crust with an iron rod.

I give the details of this experiment because I have been informed that others have experienced difficulty in carrying it out successfully.

Electrochemical Laboratory, Columbia University.

An Apparent Increase in Electrolytic Conductivity Along Lines of Magnetic Flux.

By C. J. Reed.

An accident to a submerged magnetic separator, which occurred about a year ago, caused a peculiar corrosion in the copper tube surrounding the magnet. The peculiar locus of corrosive action showed that the line of the least resistance to the electrolytic current is along the lines of most intense magnetic flux and that, therefore, there is an increased electrolytic conductivity along those lines. As no explanation has been offered by those to whom the phenomenon has been described, the writer thought that by giving the facts publicity, through the columns of Electrochemical and Metallurgical Industry, some other explanation might be found and that the matter would be of sufficient interest to induce further investigation.

FIG. 1.—CORROSION OF COPPER TUBE.

The magnet in question consisted of a steel core, 37 in. long and 2.5 in. in diameter, having 10 steel disks, 6 in. in diameter and 0.75 in. thick, equally spaced along its length, acting as circular magnetic pole-pieces of alternate *N* and *S* polarity. The spaces between the disks contained in the energizing coils and the magnet was encased in a close-fitting copper tube about 3/64 in. thick, which was intended to protect the magnet from moisture, as the apparatus is continually submerged in water (paper pulp). The magnet operates on a 110-volt circuit

The copper tube, after removal, was photographed and is shown in Fig. 1. The irregular vertical slit extending from end to end was made with a knife to facilitate the removal of the tube from the magnet. Fig. 2 shows the upper end and Fig. 3 the lower end of the tube on a larger scale. The circular lines *a* at the top and *b* at the bottom of the tube are lines of corrosion where the copper had been dissolved out, and correspond to the edges of the pole-pieces. They were, therefore, also the loci of the most intense magnetic flux. The lines *c*, corresponding to the central pole-pieces, showed no corrosion, the marks being evidently caused by the normal action of the separator in collecting particles of iron from the surrounding mass of pulp, leaving a mark in the pulpy sediment covering the general surface.

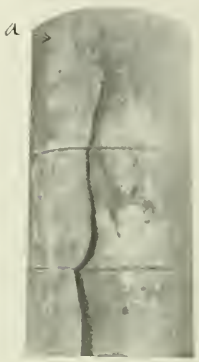


FIG. 2.—UPPER END.

FIG. 3.—LOWER END.

The presence of particles of iron on the lines *a* and *b* could not account for the corrosion at those places on any theory of local action, as the iron is electro-positive to copper. If the tube had been a zinc tube, such an explanation would have had elements of probability, but with a copper tube it could not hold.

The accident which produced the above-mentioned result was caused by a stream of paper pulp (95 per cent water) flowing continually against the lower part of the tube *d* and finally wearing away the tube and allowing the water to come in contact with the lower coils, grounding the magnet. The windings were so connected that the grounding caused current to flow from the ends of the tube into the water and from the water into the tube again at the center. This produced corrosion at the ends only. The apparatus was in this condition several weeks before the attendant located the trouble which necessitated the removal of the tube.

The peculiarity of the action is that the electrolytic corrosion of the copper was confined to the regions of most intense magnetic flux, affording grounds for the inference that the electrolytic conductivity along those lines was so enormously increased as to carry practically the total current.

Philadelphia, Pa.

Dr. **Edward G. Acheson's** portrait greets the reader from the front cover of the July issue of *The Press Scrap Book*, and the leading article of this issue is a fascinating biographical sketch of Dr. Acheson as "America's most successful discoverer in practical chemistry." The same issue contains biographies and portraits of Mr. Bion J. Arnold, the distinguished electrical engineer, of Chicago and New York; of United States Senator Simon Guggenheim, of Colorado; of Mr. Herman A. Metz, the chemical manufacturer and present comptroller of New York city ("a public official in whom the people have confidence"); of Judge Alton B. Parker, of Senator Elihu Root, and others. The whole issue, with its diversified contents, is certainly of great interest, and the mechanical make-up and the portraits are very attractive.

An Outline of a New Practical Method for the Calculation of Atomic Weights.

By Dr. Gustavus D. Hinrichs.

Every quantitative chemical analysis consists of two entirely distinct kinds of work; namely, the chemical or laboratory work proper and the reduction or calculation of the same by means of the so-called chemical constants, the atomic weights of the chemical elements. The final result of such an analysis depends equally upon both these divisions of work. If the values of the atomic weights used in the second act are not true to nature, the final numerical results of the analysis will be as surely in error as if the chemical work had been faulty while the atomic weights used were true.

For nearly 20 years I have shown in the *Comptes Rendus* of the Academy of Sciences of Paris and in the *Moniteur Scientifique*, as well as in my special books[1] of 1894 and 1901 that the so-called *Official Atomic Weights* of the American Chemical Society are not true to nature and that therefore the laboratory work done throughout the United States has been persistently falsified these many years.

This includes necessarily even the most elaborate atomic weight determination of Prof. Th. W. Richards and his school of Harvard (and now also of Berlin), published by the Carnegie Institution of Washington and in the *Journal* of the American Chemical Society, including especially the most noted of these publications in the number of said *Journal* for January, 1909, which I have just analyzed in the *Moniteur Scientifique* at Paris, having repeatedly found it impossble to get any hearing in American journals.

Thanks to the editor of the Electrochemical and Metallurgical Industry I am now permitted to address the American chemists on this most important topic and shall, in the briefest manner possible, demonstrate that the above statement in regard to the atomic weights is strictly true. Since of late it has become somewhat habitual to present the results of atomic weight determination in this country[2] in the remarkable form of a three-fold double *IF*, it will be necessary for us to go down to rock-bottom to reach solid ground for the new structure to rest upon.

I.—*The Standard of Matter* (matière étalon) adopted by us is the Diamond-Carbon; for reasons see *Comptes Rendus*, 117, 1075; 1893.

II.—*The Unit* is exactly 1/12 hereof, or $C = 12$ exactly. See Hinrichs' True Atomic Weights, pp. 20-24; Hinrichs' Absolute Atomic Weights, pp. 101-105; *Mon. Scient.*, 1909, pp. 740-742; giving $O = 16$ exactly.

III.—*The actual atomic weight* X of any element, as a matter of fact, differs by only a small fraction ϵ (*the departure*, or l'écart) from a round number (a) which we call *the absolute atomic weight* and which commonly is a whole number, sometimes ending with one-half, and rarely with one-fourth or one-eighth. Hence the true atomic weight will be represented by $X = a + \epsilon$.

IV.—*For Hydrogen* the absolute part is one and the departure is real and equal to 1/16 of 1/8, or 0.008713, which I have shown to be the weight of one atom of the primitive matter, pantogen; $H = 1 + \pi$. See *Comptes Rendus*, 147, 797; 1908.

V.—*The values of the absolute atomic weights* of the 30 elements considered in the table of values appended are, in alphabetical order:

Ag, 108; As, 75; Bi, 208; Bo, 11; Br, 80; C, 12; Cd, 112½; Co, 59, Cu, 63½; Dy, 162½; Fe, 56 or Fe', 56 − ⅛; H, $1 + \pi$; He, 4; Hg, 200; In, 115; Io, 127; Ka, 39⅛; Mg, 24 or Mg', 24¼; N, 14; Na, 23; O, 16; Pb, 207 or Pb', 207¼; Pt, 195; Ra, 226½; S, 32; Tb, 150; Te, 127½; Tl, 204; Wo, 184.

VI.—The final outcome of this research has been that the values of the departure ϵ are smallest for the most accurate chemical determinations made and that they for each element show opposite signs if several determinations have been made after independent chemical methods. See the values of the departures found in the columns headed ϵ of our table giving these departures in thousandths of the unit.

Therefore, these departures are simply residual errors of the experimental work, so that the above absolute values are the true atomic weights of the chemical elements.

VII.—Since the actually obtained departures ϵ, as a matter of fact, are quite small fractions of the unit of atomic weights, all calculations with the actual atomic weights $X = a + \epsilon$ can be carried out by proportional parts and all geometrical constructions required can be effected with straight lines.

VIII.—In this way, every given chemical reaction is specifically characterized by numerical values readily calculated and which we have named *Variations;* we represent them by the letter delta Δ.

IX.—If the value of the variation for an element in a given reaction is large, the reaction is *sharp* for that element considered and the resulting atomic weight will be a value of high precision.

If, however, the variation for the element considered be small, that reaction is called *dull* and it will not be possible to obtain a value of precision for the atomic weight of that element from the chemical reaction considered.

It will be at once apparent that *this criterion* is of the greatest practical value in the work of atomic weight determinations. See, for example, Lenher's attempt to determine the atomic weight of Tellurium: *Comptes Rendus*, 148, 484; 1909.

X.—The chemical reaction used for atomic weight determinations requires *two accurately weighable compounds*, P and Q, of which one is directly convertable into the other, best without change of the containing vessel.

XI.—For any one determination or experiment, the actual weights p and q of these compounds are taken and their ratio is calculated to five decimal places, this being the limit of the best chemical work done at present. We call this value the analytical ratio, $\rho = \frac{p}{q}$.

XII.—A certain number n of determinations is made of which the mean is taken. *The range* r is the difference between the highest and the lowest ratio found (in units of the fifth decimal). The range gives a good measure of the concordance attained in the determinations made. There is no need of calculating the probable error of the mean: we have repeatedly shown up the abuse that has been made of this chemically little important number.

XIII.—*The three numbers*, ρ, r and n, fully express the results of the laboratory work done for the atomic weight determination.

XIV.—Inserting the absolute atomic weights in the formulæ of the two pure chemical compounds used, P and Q, we can calculate *the atomic ratio* R of the chemical reaction used. For example, the combustion of the diamond (No. I of our table) gives

$$R = \frac{P}{Q} = \frac{C}{CO_2} = \frac{12}{44} = 0.27273.$$

XV.—*The Variation* Δ for any one element in such a chemical reaction is the increase of R for an increase of 0.1 in the atomic weight of that element.[1] It is understood that all calculations are made to five decimal places, and that the resulting variation is expressed in units of that place, not as a decimal.

For example, in the above case of the combustion of the diamond (No. I of the table) we find

$$\Delta C = 165, \quad \Delta O = -124.$$

XVI.—In the reduction of PbO to Pb by Berzelius we find $R = 0.02825$ and $\Delta Pb = 3$, $\Delta O = -40$; see No. 8 in our table. This reaction is, therefore, very dull for Pb; hence the result obtained is subject to doubt.

[1] The True Atomic Weights, St. Louis, 1894, XVI and 256 pp., 8vo, 7 plates. The Absolute Atomic Weights, St Louis, 1901, XVI and 304 pp., 8vo, 3 plates.

[2] *Carnegie Publication*, No. 69, p. 65, p. 87-88, 1907; also in late issues of *Journal Am. Chem. Society*.

[1] Absolute At. Wgts. 1901, pp. 64-65.

Recently Baxter used reaction No. 45 of our table which requires the absolute value 207¼. The variation for *Pb* is 10 times as great as the one for the reaction used by Berzelius; but there are other matters involved so that it will require further chemical research to definitely settle the atomic weight of Lead.

XVII.—*The analytical excess* $e = \rho - R$, is expressed in units of the fifth decimal. The mean value, in the case of lead just mentioned, is 2.1 for No. 8 and 25 for No. 45. In this regard, No. 45 is less reliable than No. 8.

XVIII.—Our *Equation of Condition* connecting the departures ϵ of the atomic weights, the analytical excess e and the variations Δ of any chemical reaction is

$$10\,\Sigma\,\epsilon\,\Delta = e + k$$

where k represents the constant error of the chemical work.

XIX.—This most important relation was first published in the *Comptes Rendus*, T. 145, p. 715; 1907. In this edition the factor was misplaced and k was included in e.

It is understood that the sign Σ comprises as many terms as there are elements involved in the chemical reaction; hence, there are at least two such terms. Consequently, this equation is always diophantic with at least two unknown; it can therefore be solved only by repeated trials—that is, by gradual approximation.

XX.—As a first approximation, we may neglect k and divide the analytical excess equally between the m elements present. By this *ex-aequo solution* we obtain as first approximation the values of the departures by

$$\epsilon = \frac{e'}{10\,\Delta} \text{ where } e' = \frac{e}{m}.$$

Compare *Comptes Rendus*, T. 145, p. 60; 1907.

Example.—Berzelius' determination for *Pb* (No. 8) gives $e = 2.1$; hence $e' = 1.05$ and since $\Delta Pb = 3$, the departure for *Pb* is $\epsilon = 0.035$; since ΔO is -40, the departure for *O* is $\epsilon = -0.003$.

XXI.—If the laboratory work does not yield satisfactory results, it must be repeated with greater care and even other chemical reactions should be tried, as already indicated in the case of *Pb* above. If no satisfactory results have been reached, the absolute atomic weight assumed may be in error.

Note.—Our graphical method, of which a preliminary publication has been made in 1907, will not be required in practice until the laboratory work has reached a higher state of precision. See *Comptes Rendus*, 145, 715-718; *Moniteur Scientifique*, 1907, 733-750, and 1908, 155-172.

XXII.—In the above indicated manner, the outstanding departures ϵ will rapidly diminish, after a few trials, since every step taken is in the open and on solid ground.

XXIII.—The adjoined table gives the results obtained from 60 chemical reactions, containing 30 different elements and giving 182 individual determinations of atomic weights—that is, an average of three per chemical reaction.

XXIV.—There are found in this (the first table of its kind) 35 independent determinations of the atomic weight of Ag and 34 for O—that is, 69 determinations for these two elements, Ag and O.

Again there are 27 determinations for chlorine and 11 for bromine—that is, 38 determinations for these two chloroids.

For Ka we find 6 and for Na 5 determinations; hence 11 determinations for these two kaloids.

These few data express in a striking manner both the novelty and the power of the new method here given.

XXV.—An examination of the details of this great table will prove exceedingly interesting and instructive. We shall return to this work in a near future, after having added sufficiently to the table here presented.[1]

In the meanwhile we trust that the reader will succeed without further assistance in the study of this table, always remembering that the departures are given in thousandths of the unit and can be properly estimated only in connection with the character of the reaction used, expressed in the variation. See IX.

The famous Reactions, 6, 35 and 36.—Prof. Th. W. Richards has practiced these three reactions in his famous work done at Harvard University and Berlin University. The Carnegie Institution of Washington has assisted him; the Warren Research Fund in Harvard and the men and means of the First Institute of Chemistry of the University of Berlin were at his service.

The results of this research were published in the *Carnegie Publication* No. 69, of 1907, and in the January number of the *Journal* of the American Chemical Society for 1909. This last publication gives the details for Reaction No. 35 of our table, and the general results for all three, including as particularly important the mode of calculation actually used by Professor Richards (p. 19) so as to leave no possibility for doubt about this all important matter.

Professor Richards in his publications informs his readers at nearly every operation about the perfection of his work; for example, on page 20 of the journal cited, he declares: "These analyses were superior to any other that have ever been made." Besides he does not omit to declare (l. c., p. 7) "most of the previous work is unsatisfactory" and notably Stas' work and materials were regretfully inferior. In this connection I may admit that I have never seen any other chemist than Richards omit 4 of every 10 of his determinations without saying much about it; by selecting 6 out of 10 made, the show may be considerably improved even at a fine stock show. See l. c., p. 18.

However, we have given the results of the laboratory work of Professor Richards exactly as he reports it (see our table, Nos. 6, 35 and 36). We find for the atomic weight of silver the following departures (in thousandths of a unit) from the absolute value of 108:

No. 6, 5 high. No. 35, 17 low. No. 36, 45 low.

The mean of these three is 19 low, giving Ag 107.981. But the reaction No. 36 has been shown to be unfit for accurate atomic weight determinations on account of the large systematic errors the results present (see *Moniteur Scientifique*, 1908, p. 454-457; 1909, p. ii-16).

This leaves only Nos. 6 and 35, which give the mean of 6 low making Ag 107.994. There can be no possible question about this being the only result obtainable from the laboratory work as it is published by Richards himself in the periodicals mentioned.

XXVII.—In the January number of the *Journal* of the American Chemical Society (p. 20), Professor Richards gives the entirely different value Ag 107.881 and the number 107.88 has already made its appearance in chemical literature. Its departure from the true value which is confirmed by the laboratory work of Professor Richards himself as just shown (XXVI) is 0.12 on 108, which is 1 in 900, or decidedly more than one-tenth of one per cent, an amount which is very great in this branch of chemistry; indeed, such a difference would make quite an error in any quantitative analysis.

In a paper of which I have read the proof and which is to appear in the June number[2] of the *Moniteur Scientifique* at Paris, I have shown how Professor Richards, in his mode of elimination (given by himself, l. c., p. 19) considers three really quite different weights to be identical as soon as he designates them by one and the same algebraic symbol. Such mathematical dreams (even if indulged in while in a chemical laboratory, whether of the University of Harvard or of Berlin) will wipe out the best of real chemical work done in any chemical laboratory of the world, and no blindly admiring school can prevent such astounding errors to be shown up—outside of the United States and of Germany—say, in France.

XXVIII.—The history of chemistry does not furnish a par-

[1] The ratio No. 11 should have the third decimal 9 instead of 0; it should read 0.79937

[2] This number has just reached me and contains the article, pp. 383-388.

No	Reaction	R	Δ	Δ	Δ	Δ	ε	r	n	ε	ε	ε	ε	#642.
1	$C : CO_2$	0.27273	C 165	O −124			0.9	95	15	C 0	O 0			Dumas 1842
2	$TlNO_3 : Tl$	1.30392	Tl −15	O 148	N 49		−0.8	5	10	Tl 2	O 0	N 0		Crookes 1872
3	$2NaCl : Na_2B_4O_7 5H_2O$	0.57921	Na 41	O −200	Cl 99	Bo −115	9	68	5	Na 6	O −1	Cl 2	Bo −2	Ramsay 1893
4	$Cu : CuSO_4 5H_2O$	0.25451	Cu 30	O −92	S −10	H −102	1			Cu 1	O 0	S −3	H 10	Richards 1892
5	$Na_3AsO_4 : 4NaCl$	0.66102	As −38	O −131	Cl 113	Na 38	−4.3	60	7	As 3	O 1	Cl −1	Na −3	Smith, E.F. 1896
6	$AgCl : Ag$	1.32870	Ag −30		Cl 93		−3	8	10	Ag 5		Cl −2		Richards 1905
7	$Bi_2 : Bi_2O_3$	0.89655	Bi 5	O −58			0.2	18	16	Bi 2	O 0			Gutbier 1904
8	$Pb : PbO$	0.92825	Pb 3	O −40			2.1	15	9	Pb 35	O 3			Berzelius 1830
9	$Hg : HgO$	0.92593	Hg 3	O −43			6.6	12	5	Hg 110	O −8			Erdm. Mchd 1844
10	$Fe_2 : Fe_2O_3$	0.70000	Fe 37	O −131			1.5	144	14	Fe 2	O −1			Svanberg 1844
11	$Te : TeO_2$	0.79037	Te 13	O −100			14	15	8	Te 54	O −7			Gutbier 1904
12	$N_2 : N_2O$	0.63637	N 165	O −149			13	50	5	N 4	O −5			Guye, Ph. 1904
13	$2Ag : Mn Br_2$	1.00465	Mn −47		Br −93	Ag 93	−1	7	15	Mn 1		Br ½	Ag −½	Baxter 1906
14	$2Ag : Cd Br_2$	0.79266	Cd −29		Br −58	Ag 73	−15.5	8	8	Cd 2		Br 9	Ag −7	Baxter 1906
15	$2Ag : Co Cl_2$	1.66154	Co −128		Cl −255	Ag 154	−34	18	8	Co 9		Cl 4	Ag −7	Baxter 1906
16	$In Cl_3 : 3AgCl$	0.51452	In 23		Cl 34	Ag −36	−10	36	6	In −15		Cl −10	Ag 9	Mathers 1907
17	$Pt : N_2H_6Cl_6Pt$	0.43913	Pt 13	N −20	Cl −59	H −79	−3	71	12	Pt −6	N 4	Cl 1	H 1	Seubert 1881
18	$Sate : hydr. Sate$	0.80800	Tb 5	O −55	S 8	H −172	2	6	5	Tb 10	O −1	S 6	H 0	Urbain 1906
19	$Ra Cl_2 : 2AgCl$	1.03659	Ra 35		Cl −3	Ag −73	−0.5	15	2	Ra −1		Cl 6	Ag 0	Mme Curie 1907
20	H	1.00781	H	He		π		59		H 0		He 0	π 0	Noyes 1907
21	$2KaCl : Ka_2TeBr$	0.21765	Ka 23	Te −3	Cl 29	Br −19	−5	4	16	Ka −5	Te 42	Cl −4	Br 7	Lenher 1909
22	$kaCl : KaClO_3$	0.60856	Ka 32	O −148	Cl 32		−7			Ka −6	O 2	Cl −6		Stas 1860
23	$AgCl : AgClO_3$	0.74935	Ag 13	O −117	Cl 13		−14.5			Ag −28	O 6	Cl −28		Stas 1860
24	$AgBr : AgBrO_3$	0.79661	Ag 9	O −101	Br 9		−11			Ag −31	O 5	Br −31		Stas 1860
25	$AgIo : AgIoO_3$	0.83039	Ag 6	O −83	Io 6		−13			Ag −54	O 8	Io −54		Stas 1860
26	$AgNO_3 : Ag$	1.57407	Ag −53	O 278	N 93		73			Ag −34	O 14	N 19		Richards 1907
27	$Dy_2O_3 : Dy_2(SO_4)_3 8H_2O$	0.49273	Dy 14	O −90	S −19	H −103	−14.4	62	12	Dy −27	O 4	S 20	H 4	Urbain 1907
28	$NaCl : Ag$	0.54167	Na 91		Cl 92	Ag −50	18	4	10	Na 7		Cl 7	Ag −12	Richards 1905
29	$NaCl : AgCl$	0.40767	Na 69		Cl 41	Ag −29	13	4	10	Na 5		Cl 8	Ag −11	Richards 1905
30	$KaCl : Ag$	0.69097	Ka 93		Cl 93	Ag −64	10	3	7	Ka 4		Cl 4	Ag −5	Richards 1907
31	$KaCl : AgCl$	0.52006	Ka 69		Cl 33	Ag −38	−8	2	5	Ka −4		Cl −8	Ag 7	Richards 1907
32	$KaBr : AgBr$	0.63364	Ka 53		Br 20	Ag −33	9	2	4	Ka 6		Br 15	Ag −9	" "
33	$KaBr : Ag$	1.10301	Ka 92		Br 92	Ag −102	18	7	11	Ka 7		Br 7	Ag −6	" "
34	$2AgCl : Ag_2SO_4$	0.91987	S −29	O −118	Cl 64	Ag 4	−54	7	10	S 41	O 11	Cl −23	Ag −338	" (Hensgen R.)
35	$NH_4Cl : AgCl$	0.37304	N 70	H 279	Cl 44	Ag −26	18	4	9	N 6	H 2	Cl 10	Ag −17	" 1909
36	$AgNO_{3.0216} : Ag$	1.57407	Ag −53	O 278	N 93		73			Ag −45	O 9	N 26		" 1907
37	$Wo : WoO_3$	0.79310	Wo 9	O −102			6		6	Wo 33	O −3			Smith, E.F. 1904
38	$WoO_3 : WoCl_6$	0.58438	Wo 11	O 76	Cl −88		45			Wo 137	O 19	Cl −17		" 1904
39	$Ag_3AsO_4 : 3AgCl$	1.07549	As 24	O 94	Cl −75	Ag −5	43	38	8	As 46	O 12	Cl −13	Ag −220	" 1901
40	$Ag_3AsO_4 : 3Ag$	1.42901	As 31	O 124		Ag −39	24	56	7	As 25	O 7		Ag −20	" 1901
41	$2Ag : IO_3O_5$	0.64671	Ag 60	O −97	To −39		−48		18	Ag −27	O 16	Io 41		Baxter 1909
42	$3AgBr : Ag_3AsO_4$	1.21814	As −26	O −105	Br 65	Ag −14	−20	14	11	As 19	O 9	Br −8	Ag 36	" "
43	$3AgCl : Ag_3AsO_4$	0.92981	As −20	O −81	Cl 64	Ag 4	−20	5	15	As 25	O 6	Cl −8	Ag −125	" "
44	$Pb Cl_2 : 2Ag$	1.28819	Pb 47		Cl 93	Ag −119	29	13	9	Pb 21		Cl 10	Ag −8	" 1908
45	$Pb Cl_2 : 2AgCl$	0.96951	Pb 35		Cl 2	Ag −67	25	33	6	Pb 24		Cl 9	Ag −7	" "
46	$AgBr : Ag$	1.74074	Ag −68		Br 93		5	14	18	Ag −4		Br 3		" 1906
47	$AgBr : AgCl$	1.31010	Ag −21	Cl −91	Br 70		7.5	6	13	Ag −12	Cl −3	Br 4		" "
48	$2AgBr : MnBr_2$	1.74884	Mn −81		Br −70	Ag 93	5	25	16	Mn −2		Br −2	Ag 2	" "
49	$2Ag : Mn Cl_2$	1.71429	Mn 136		Cl −272	Ag 158	18	9	7	Mn −4		Cl −2	Ag 4	" "
50	$2AgCl : Mn Cl_2$	2.27778	Mn 181		Cl −282	Ag 158	20	23	7	Mn −4		Cl −2	Ag 4	" "
51	$2AgCl : Ag_2CrO_4$	0.86446	Cr −26	O −104	Cl 60	Ag 8	−37	9	3	Cr 35	O 9	Cl −15	Ag −115	Baxter 1909
52	$2AgBr : Ag_2CrO_4$	1.13253	Cr −34	O 124	Br 60	Ag −8	−46	17	11	Cr 34	O −9	Br −19	Ag 144	" "
53	$2Ag_2Br : Ag_2Cr_2O_7$	0.87037	Cr −40	O −141	Br 46	Ag 6	−51	9	9	Cr 32	O 9	Br −27	Ag 213	" "
54	$Mg Cl_2 : 2Ag$	0.44097	Mg 24		Cl 12	Ag −28	34			Mg 24		Cl 12	Ag −28	Richards 1896
55	$Fe_2 : Fe_2O_3$	0.69953	Fe 37	O −131			3	8	5	Fe 4	O −1			" 1900
56	$Hg : HgS$	0.86207	Hg 7	S −37			6		4	Hg 43	S −8			Erdm. Mchd 1844
57	$Hg : HgCl_2$	0.73801	Hg 9		Cl −55		16		3	Hg −33		Cl 5		Svanberg 1848
58	$Hg : HgCl_2$	0.73801	Hg 9		Cl −55		−10		2	Hg −56		Cl 9		Turner 1833
59	$MgO : MgOCO_2$	0.47619	MgO 119	CO_2 −6			−11			MgO_5 −CO_2 91				Mchd. Schr. 1850
60	$Na_2B_4O_7 : 2AgCl$	0.70383	Bo 139	O 244	Na 70	Ag −99 Cl −49	163	121	5	Bo 24	O 14	Na 47	Ag −67 Cl −67	Ramsay 1893

allel to this stupendous error, or rather system of errors, which has for years been forced upon the unsuspecting members of the American Chemical Society in the Annual Reports on the Atomic Weights. The sixteenth has appeared in the March number, 1909.

I do not like to express my own opinion on this annual gamble in atomic weights; I therefor quote the closing part of a most striking and true editorial which, while written without any knowledge of the case in hand, surely lays bare the modus operandi thereof:

"It is all very well to speak of the tendency of the times to form commercial combinations and trusts for manufacturing on a large scale. But science, pure and applied, is promoted not in such a way. What counts here is individuality, the man as man. Great advances are made by opposing individualities. For the promotion of science and engineering, even in a limited field like chemistry only, nothing could be worse than the combination of the various scientific and engineering societies into one unit, with one publication committee and an editor in charge who as a practical dictator would determine what is suitable for publication and what not. It is unnecessary to add another word."

Personally I feel sure to say that it is unnecessary to add where this editorial was first published.

XXIX.—The United States Pharmacopœial Commission accepted these false atomic weights as standards for the eighth revision now in force in this country.

My endeavor to prevent this was vox elamantis in deserto. See, for example, my articles in *The National Druggist*, St. Louis, from November, 1900, to March, 1901.

XXX.—Finally, to cap the climax, our National Congress passed a pure food bill in which this Pharmacopœia is accepted as the standard and the President of the United States by signing the bill made it law for this country.

Accordingly the system of false atomic weights has become a part of the law of the land and the best work done in the chemical laboratories of the United States must be falsified by the use of the false atomic weights legalized by Congress and the President; and, as if this were not bad enough, as a technical absurdity, the action of our Government reaches much farther; for it includes the condemnation of the broadest principle of modern science: The unity of matter.

History furnishes but one single parallel to this action of a non-scientific governing power condemning a scientific truth and we have to turn back many pages of the book of history, the record of a number of centuries, to reach that single precedent.

It was at the close of the Dark Ages that the Church at Rome (through certain institutions and officers of its own) did what the State at Washington (through Congress and President) repeated at the opening of this, the twentieth century.

St. Louis, Mo.

The Efficiency of Induction Furnaces.

By Joh. Härdén.

In Electrochemical and Metallurgical Industry, Vol. VII, No. 1, this subject is discussed in an article by Mr. F. A. J. FitzGerald.[1]

In the following article we will give some more particulars of results obtained in a 60-kw experimental induction furnace erected by the Gröndal-Kjellin Company, Ltd., in London, together with a few explanations and comparisons.

It may be useful to first settle the question: What is meant by "the efficiency" of the furnace, and what are the factors which influence the efficiency of the plant?

The theoretical efficiency may be classified as thermal and total efficiency.

We require a certain amount of heat to melt and superheat a given quantity of steel, and this may be expressed in a number of calories, to be supplied by means of electric power.

The heat required to melt, say, 1 kg of steel, divided by the number of calories supplied in kw-hours will give us the efficiency of the furnace.

The thermal efficiency is derived from the power actually taken up by the charge, including the losses by radiation, slag, etc.

The total efficiency is determined from the total amount of power supplied to the furnace, including the above losses as well as all the electrical and magnetical losses.

The electrical losses are composed of Joulean heat losses in the primary coil, in the leads, and of eddy currents.

The power factor has a great influence upon these losses, because with a low power factor of, say, 50 per cent, we have to supply about 50 per cent more kilovolt-amperes to the furnace than what is actually utilized in the charge. The "wattless current" will increase the electrical losses both in the furnace, the cable and the generating plant without any gain. It is, therefore, essential that the power factor should be high.

We must admit, however, that these losses are comparatively small compared with the total expenditure of power in a large furnace, but they may be a serious item in a furnace of smaller or medium size, say, up to 150 kw capacity.

The magnetic losses are due to hysteresis in the iron core and are influenced by the permeability of the iron, the magnetic saturation and the frequency.

It is, therefore, necessary for the furnace designer to consider the cost of the losses compared with the price of the iron; then it is not always wise to make use of iron of the highest permeability because of its higher price. Where power is cheap, a lower grade of iron may be more profitable in the long run.

A compromise must also be made between the magnetic saturation and the frequency available; but, again, a higher frequency means a lower power factor, so this must be subject to careful calculation based upon actual experience.

The curves shown in the diagram (p. 322) demonstrate the approximate decrease of the power factor at higher frequency.

The magnetic saturation has also to some extent an influence upon the working of the furnace; it is not permissible to follow the usual practice in an ordinary transformer, for several reasons.

Also the mechanical design of the iron core will have an influence upon the efficiency, inasmuch as the lack of uniformity of the magnetic leakage field, caused by the counteraction of the secondary circuit, i.e., the charge, may set up heavy eddy currents in the bandage of a badly designed iron core.

It is rather difficult to determine the electric and magnetic losses separately, as their proportions will be altered with the charge. A full charge will cause a stronger leakage field than a small charge, and vice versa.

The separation is also quite immaterial from a practical point of view. It has been ascertained during a long series of runs that the electrical and magnetical losses together will amount to 5.5 to 6.5 per cent of the total energy.

What will interest the steel maker much more is the total efficiency of the plant, i.e., how much has he to spend in power in order to melt a given quantity of steel, in this way or that.

The chief source of the losses is to be found in heat radiation, both from the open surface of the bath and through the furnace walls. The bath is, of course, protected with slag, and also by means of brick-lined iron covers. But in spite of this, some of the heat will escape.

In the early days the lining was built up of firebrick, but regardless of other troubles, because of their great expansion coefficient, the heat conductivity proved rather excessive.

The lining used to-day is stamped in from powdered magnesite or dolomite, with a heat insulation layer between the lining and the furnace wall; this also serves to compensate for the expansion.

[1] See Also Vol. VI, No. 11, p. 439.

As a rule, the following formula for the calculation of the heat conductivity and thickness of the lining may be assumed to be approximately correct:

$$W = \frac{ta}{l} c$$

Where W = amount of heat, expressed in watts conducted from one surface of the wall to the other

t = temperature difference in centigrades.
a = mean surface in square meter.
l = thickness of the wall in meter.
c = coefficient of specific heat conductivity.

This coefficient may be found for various materials in several handbooks, such as "Die Hütte" and others.

If the amount of the total loss is given in percentage, it is thus easy to calculate the required thickness of the wall by means of the above formula, if the conductivity coefficient of the lining material is known.

In practice, however, the thickness of the lining is much less dependent upon a few more or less kilowatts lost by radiation.

The *total* cost per ton of steel, in dollars and cents, is the important question. The corrosive action of the slag upon the lining, and consequently the life of the latter, compared with the cost of relining and material, is to be carefully considered. Therefore, it would be idle to put down a general rule, as the question must be settled individually in each case.

When the power is usually paid for per kw-year, the stoppage for repairs is also an item which will lower the total year-efficiency. A magnesite lining will last, on an average, for eight to nine weeks, but linings have been in use for as long as three months.

The writer has, in order to minimize this source of inefficiency as much as possible, designed an arrangement with interchangeable hearths, patented by the Gröndal-Kjellin Company, Ltd. In this way it is possible to replace a defective lining with a new one in less than half an hour, while the actual re-lining can be carried out at leisure with cheap labor. Part of the old lining material may be used over again if the slaggy parts are removed.

Care must be taken that the lining is not too porous. A moderately porous lining would have a lower heat conductivity and thus give better efficiency, but in the case of the lining being too porous the steel would gradually penetrate through the inner wall of the furnace in the shape of narrow needles.

These do not cause the steel to flow out because they will soon solidify; but the heat is rapidly conducted from the bath to the cooling mantle, thus lowering the efficiency considerably.

Besides, these needles, if they are allowed to occur, will form an easy path for the magnetic leakage, whereby the electrical efficiency will also be materially lowered. The power factor has been observed to be lowered nearly 20 per cent in a large furnace where such needles were permitted to develop. They formed a huge bundle like a wasp's nest and weighed nearly 100 lb.

The heating up and burning in of the lining also, of course, consumes power which is, in one sense, wasted, but as the lining will last for a comparatively long period and the total time used for this purpose is only about eight hours at about one-half of the normal power, this item is not of great importance. Fuel will have to be spent in any furnace for this purpose. We have therefore, omitted to include this in the following calculations:

A small furnace will of necessity waste a larger amount of power for this purpose compared with a larger furnace. The 60-kw furnace mentioned below will require about 160 kw-hours for this purpose, while only a little more will be needed in a furnace of three or four times the capacity of the former.

We will now set forth the fundamental quantities upon which our calculations are based, so as to enable us to determine the total efficiency in each case.

According to the c.g.s system of units, 1 watt is equal to 1/9.81 kg-m; the mechanical equivalent of heat is 424, or, in other words, 1 calorie is equal to 425 kg-m. Consequently, 1 kw-hour equals 864.5 kg-calories.

The pouring temperature of cast steel may be given at about 1525° C.; some steel may require a higher and some a lower temperature, but this may be taken as an average.

The specific heat of cast steel is stated by Neumann, Jüptner and others to be from 0° C. to 1300° C. = 0.20, and above this in average = 0.48.

Thus we find: $1300° \times 0.2 = 260$ and $225° \times 0.48 = 108$ or a total of $260 + 108 = 368$ calories. We may, in order to be on the safe side, say that we require 370 calories to melt and superheat 1 kg of steel, theoretically.

As one kw-hour is equal to 864 calories (in round figures) we should obtain $864 \div 370 = 2.335$ kg of steel for each kw-hour or that one kilogram of molten and superheated steel would require 0.428 kw-hour, if there were no losses whatever.

From this we are now able to determine the total efficiency by the formula

$$E = 0.428 \times 100 \times W \div K$$

Where E = total efficiency of the furnace,
W = weight of steel in kilograms,
K = kw-hours spent.

We reproduce below a few records taken from the 60-kw furnace mentioned before and also some figures from the furnace mentioned on page 10, Vol. VII, of Electrochemical and Metallurgical Industry.

In some cases, ample time was given for the steel to "set" before tapping, which, of course, has nothing to do with the actual melting.

RECORD OF MELTING—60-KW FURNACE.

No. 1.

Time.	Volts.	Amp.	Kw.	Power factor.	Remarks.
9.00	110	182	18	....	Charge 60 kg
9.05	176	290	43	....	
9.22	192	321	49	0.79	
10.15	180	305	44	....	
10.35	185	318	48.5	....	
11.00	190	325	50	0.81	Teeming

Average kw = 42.08.
Total kw-hours spent = 84.16.
Molten and superheated metal = 60 kg.

$$\text{Efficiency} = \frac{0.428 \times 100 \times 60}{84.16} = 30.5 \text{ per cent.}$$

No. 2.

Time.	Volts.	Amp.	Kw	Power factor.	Remarks.
2.25	180	230	35	....	Charge 76 kg
2.40	193	324	50	0.80	
3.00	188	342	49.6	....	
3.30	180	352	49	0.795	

Average kw = 45.9.
Total kw-hours spent = 50.6.
Efficiency = 64.2 per cent.

No. 3.

Time.	Volts.	Amp.	Kw.	Power factor.	Remarks.
2.15	192	325	49	0.785	Charge 32 kg
2.40	192	325	43	....	
2.50	192	325	43	....	

Average kw = 45.
Total kw-hours spent = 26.25.
Efficiency = 62 per cent.

It must be noted that in charge No. 2 a portion of hot steel was left in the furnace from the previous charge, assumed to be about 22 kg. As this was already molten, but became very chilled during the re-charging, the efficiency figure may be somewhat too high in this case, but we are justified in assum-

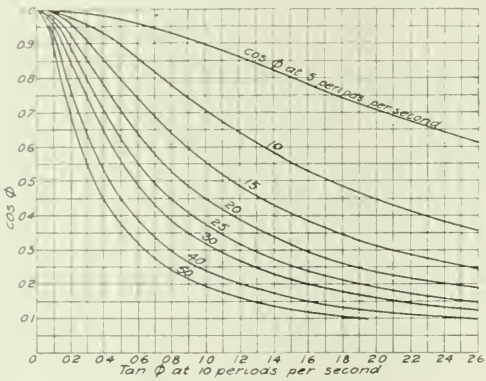
ing that the average efficiency is between 40 and 50 per cent, taken over a series of meltings.

RECORD TAKEN FROM THE 125-KW FURNACE.

Time	Volts.	Amp.	Kw.	Power factor.	Remarks.
11.25 A.M.	590	225	105	0.79	Start heating, 381 kg left from previous charge.
11.35	584	240	115	0.82	Charge 91 kg pig iron.
11.4	574	252	118	0.81	Charge 91 kg bar ends.
12.x	569	262	120	0.80	Charge 100 kg scrap ingots.
12.1x	567	268	122	0.80	Charge 45 kg pig iron.
12.2x	569	270	123	0.80	Charge 45 kg pig iron.
1.0x P.M.	554	272	120	0.80	Ready to teem.

Yield of steel = 372 kg.
Total power spent = 220 kw-hours.
Total efficiency = 72.4 per cent.

As will be seen from the above, the efficiency of this furnace is considerably higher than in the 60-kw furnace, owing to the possibility of treating a much larger quantity of metal in a



CHANGE OF POWER FACTOR WITH FREQUENCY.

shorter time. In fact, melts have been made in this furnace at which the efficiency was well over 76 per cent with forced melting.

The above figure shows that steel can be made with an expenditure of 590 kw-hours per metric ton or even less, with forced melting.

In ordinary practice, however, the melting period will have to be somewhat prolonged for several reasons.

It has not been found practical to make more than six charges in 24 hours, when a high-grade tool-steel should be produced, even if the furnace was designed to permit 8 or 10 charges.

The reason for this is that the steelmaker requires that the steel should be given what he terms a "killing time"; after proper melting and mixing (which is done automatically in the furnace owing to the strong evolution of the charge, caused by the magnetic action) the steel is usually left in the furnace for some time, at a moderately high temperature. During this time most of the gases are expelled and the charge becomes calm and will not cause blow-holes in the ingots.

Different raw materials may require different "killing time," but records taken over several months run in a larger furnace show that ordinary tool-steel requires about 650 kw-hours per metric ton, while the highest grade may require from 750 to 800 kw-hours in a furnace of 1½ to 2 tons capacity.

Now, if we assume that power will be purchased at a rate of $18 per kw-year, which seems a reasonable figure (in a large steel works, where blast furnace gas is available for the purpose, it may even cost only $12.15 yer kw-year), we find that the kw-hour will cost about 0.2 cent.

Applying this to the above figures, we see that the cost of power for melting one (metric) ton of tool-steel will be $1.30 and $1.60 respectively.

Even if we include all losses caused by stoppage during relining, etc., the melting costs should not exceed $2 per ton, which will be found to compare favorably with the coke-crucible furnace, especially if we consider the great saving in labor, as only three men per shift are required for the operating of a 2-ton induction furnace.

London, England.

Electric Furnace in the Iron and Steel Industry

Mr. P. McN. Bennie, of the FitzGerald & Bennie Laboratories, Niagara Falls, N. Y., lectured, on June 10, at Harrisburg, before the newly founded Engineers' Society of Pennsylvania, on the relation of electric furnaces to siderurgy. He first gave a review of what has actually been done with respect to the reduction of iron and the making and refining of steel in electric furnaces. Since all these matters have been very fully covered in the past in this journal, it is the final conclusions of Mr. Bennie which will be of special interest to our readers.

First, as to high-grade steel, the electric furnace is rapidly becoming a serious competitor of the crucible method, for the simple reason that it is less expensive. Against a high cost for labor, crucible renewals, and the fact that steel must be melted in small units, we have a lower labor cost, small cost for refractories, and the possibility of handling several tons of metal of uniform composition.

Second, as to steel for structural and rail purposes the electric furnace is so far only asking recognition as a useful adjunct to existing apparatus, for doing additional refining or treatment in an economical and expeditious manner. Not a rival, but an ally, in the general siderurgical scheme.

Third, for steel castings, the electric furnace cannot compete with open-hearth castings, but for a grade somewhat better, where additional refining would be required, the electric furnace has decided advantages. For castings of crucible quality the electric-furnace methods will give satisfactory results at less cost than crucibles. In addition for heavy castings the larger quantity of metal which can be treated as a unit is of much more importance.

It is a fact that higher temperatures are at the command of the metallurgists in electric furnaces. Generally speaking, refining is more rapid and thorough with higher temperatures. Whether any good is accomplished by additional refining must be left to the steelmakers to decide.

"I heard it said recently by a metallurgical engineer that product with just as good analysis could be made in any ordinary furnace as in the electric furnace. The truth of this contention is granted, but not the implied conclusion that analysis is the whole story. Given a choice between two steels of identical price and analysis, one of which is known to be the product of the crucible process and the other of the open-hearth process, would any engineer hesitate?"

As to the electric furnace, if it can produce an improvement in quality, worth more than the increased cost, its future is assured. All electric-steel furnaces work under basic conditions, even those used for tool steels. It has been found in Germany, for example, that steel is improved by simply putting it into an induction furnace, leaving it there for an hour or two without attempting any refining by slags, meanwhile supplying only sufficient energy to maintain the temperature. It is believed that this gives dissolved gases an easy opportunity to escape.

Finally, Mr. Bennie expects the following improvements to be made:

Electrodes of larger size, and quality that will reduce the present consumption per ton.

Refractory materials superior to those now in use, and probably themselves the product of electric furnaces, such as fused alumina and other refractory oxides. In electric furnaces where an arc is present there is considerable vapor formed by volatilization of silicon, calcium, calcium oxide, and even iron itself, which vapors are very active chemically, attacking the walls and roof of the furnace. The destruction of the roof in electric furnaces is probably due as much to these vapors as to the high temperatures.

Finally we may expect an increase in size and capacity of furnaces. This development has already started with the 15-ton Héroult furnaces of the United States Steel Corporation.

"When it is considered that electric furnaces charged with molten metal are good for 10 heats daily, it will be seen that with a total daily capacity of from 100 to 150 tons of steel, the electric furnace may fairly be said to have emerged the metallurgical nursery."

Girod Electric Steel Furnace.

As well known to our readers from descriptions in our Vol. VI, pages 428 and 452, the Girod electric steel furnace is an arc furnace like the Héroult, but differs from the latter in one important respect. In a single-phase Héroult furnace there are two electrodes on top, operating in series; the current passes from one electrode in form of an arc into the slag, through the

PAUL GIROD.

slag, and out of it again in form of another arc into the other electrode. In a single-phase Girod furnace there is only one electrode on top, while steel pieces embedded in the bottom of the furnace (water-cooled from the outside) form the other terminal of the electric circuit; the current passes from the electrode at the top in form of an arc into the slag and then downward through the molten charge, leaving the furnace through the bottom.

Considerable details on the working of this furnace were given in Mr. Paul Girod's American Electrochemical Society paper, published in our June issue, page 259, while the general plan and arrangement of the works of the Société Anonyme Electrometallurgique Procédés Paul Girod, erected at Ugine, in Savoy, France—the largest electric steel works now in existence and course of erection—were described in our January issue, page 9.

We are glad to give here, together with the portrait of the distinguished inventor, illustrations of two Girod furnaces installed and in operation at Ugine. Fig. 1 is an 8-ton to 12½-ton furnace; Fig. 2 a 2-ton to 3-ton furnace.

The Girod electric steel furnace is now being used by the following concerns:

Cie des Forges et Aciéries Electriques, Paul Girod, Ugine, France.

Oehler & Company, Aarau, Switzerland.

Société An. John Cockerill, Seraing, Belgium.

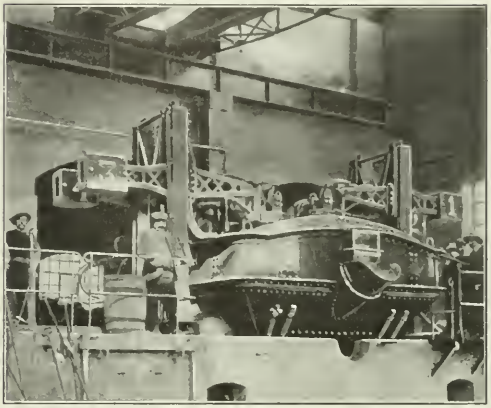


FIG. 1.—8-TON TO 12½-TON GIROD FURNACE.

Stotz & Company, Stuttgart, Germany.

Ternitzer Stahlwerke, Ternitz, Austria.

Steirische Gussstahlwerke, Danner & Company, Vienna, Austria.

Poldihütte, Altkladno, Austria.

Marrel Frères, Rive-de-Gier, France.

It is interesting to note, that, as we hear from Messrs. C. W. Leavitt & Company, of New York (the American agents for the Girod furnace), "the owners of the Girod process are ready to guarantee the perfect working of a 25-ton Girod furnace for refining steel previously molten in a Martin furnace. However, M. Girod contends that a comparison of two kinds of steel of exactly the same final composition, but manufactured by different methods, viz., one by molten charge refined in the electric furnace, and the other manufactured exclusively in the

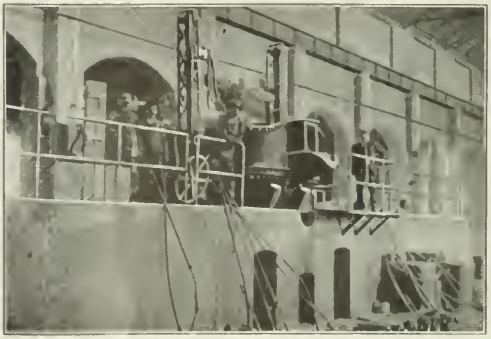


FIG. 2.—2-TON TO 3-TON GIROD FURNACE.

electric furnace from cold charge, will show that the latter gives the best results, and that the metal refined from molten charge will not show the same good qualities, namely, not the same resistance to shock; and with regard to tool steels not the same hardness nor the same tenacity and durability after hardening." (See also p. 263 of our last issue.)

SYNOPSIS OF PERIODICAL LITERATURE

In addition to the report, found elsewhere in this issue, on the recent International Congress of Applied Chemistry in London, we herewith give abstracts of a number of further congress papers.

Congress of Applied Chemistry.

Evolution in Applied Chemistry.—Otto N. Witt delivered a general lecture on this subject. It was pointed out that the simple daily wants of mankind in a primitive state were supplied by nature. The progress of civilization, however, necessitated a transformation of these gifts, which culminated in the birth of industrial chemistry. In this manner there arose a new creation, which was helped along its way by sound empiricism. Nature was forced to divulge her innermost secrets, and empiricism was quite content to pick up the treasure it might come across in its ramblings through the unexplored regions of science. New fields were continually being opened, and the process was as active to-day as ever. An example of this evolution is to be found in Norway at the present time. A new chemical industry of vast dimensions is being exploited which differs fundamentally from those of older commercial centers. Its factories will have no chimneys nor fires. They will be operated by "white coal," the force of roaring waters. The problem before older engineers was to convert heat into electricity, but in Norway the exact reverse is required. The history of applied chemistry is teeming with examples where the survival of the fittest meant neither more nor less than a a victory of economy. (London *Electrical Review*, June 11.)

Thermochemical Notation.—W. N. Hartley proposes that a uniform system of thermochemical notation be adopted. He has employed the terms "gram heat-unit" and "kilogram heat-unit" in a contracted form, instead of the small and large calorie, in order to avoid any possible misunderstanding as to their values. The abbreviations for the gram and kilogram now recommended for adoption by Lord Rayleigh are gm and kgm. According to Buchanan's notation the gram unit of heat or small calorie becomes a gram-degree Celsius, gm° C, and the large calorie a kilogram-degree Celsius, kgm° C (plural kilogram-degree Celsius, kgm° C). Similarly he recommends to denote the British thermal unit by pound-degree Fahrenheit, lb. ° F. He also recommends that J. H. Pollak's method of writing thermochemical equations be adopted. (From advance sheets.)

"Analyzed Chemicals."—This is the subject of a paper by J. T. Baker (J. T. Baker Chemical Company). "Analyzed Chemicals" represent one of the latest efforts on the part of the manufacturing chemist to furnish the analytical chemist with chemical reagents of the highest degree of purity attainable under conditions limited by skill and economy and labelled in a manner which can be intelligently understood. The common method of designating a chemical as "C. P." has resulted in much confusion owing to the fact that "chemically pure," strictly speaking, is impracticable. A chemical accompanied with a statement of analysis affords both a standard of purity and at the same time a guarantee of quality. The analysis states in definite terms the highest degree of purity attained and is in itself a guarantee in regard to which there can be no misunderstanding. The analysis states in definite terms the amount of impurity present calculated in percentage from samples large enough to obtain a determinable amount of impurity which may be present. Although the amount of impurity present, as shown by the analysis, may be insignificant, it is a source of satisfaction to the chemist, and affords an assurance which cannot be obtained in any other way. The object aimed at is to get away as far as possible from the errors of "personal equation" by getting results down to a mathematical basis. (From advance sheet.)

Photochemical Deterioration of Oil Paintings.—Maximilian Toch refers to the fact that all oil paintings show unmistakable signs of age; the whites turn yellow, and wherever a glaze of asphaltum is used, this turns brown. He showed that linseed oil, in the presence of lead and zinc pigments (principally lead pigments) change the coloring matter in bleached linseed oil, which is xanphophyll, by reduction into chlorophyll, and that when oil paintings that have turned yellow through this reduction are placed in bright sunlight they bleach again into their original condition. He furthermore shows that the tempera painting of the ancients and the method of painting with resins, like dammar, do not produce this age effect.—(From advance sheets of paper.)

Sulphur Dioxide Determination.—T. Lyndon Briggs deals with the determination of sulphur dioxide in dry gases and discusses Orsat apparatus made available for the purpose by use of chromic acid in concentrated phosphoric or sulphuric acid solution.—(From advance sheet.)

Fuel Testing.—In a joint session of Section I and II a resolution was adopted that "the percentage of volatile matter in fuel shall be that which is found by subtracting from 100, the yield of coke, obtained by the method of the American Committee on Coal Analysis—the percentage being calculated upon the pure combustible matter."—(The *Engineer*, London, June 11.)

Fused Silica and Ceramic Castings.—The fine exhibits of fused silica ware of the Thermac Syndicate, described by J. F. Bottomley, and the ceramic castings exhibited by G. Keppeler, attracted considerable attention. The latter are an invention of Weber, of Schwepnitz, in Saxony, and have been improved by Keppeler and Spangenberg. By adding alkali salts to certain clays, a kind of emulsion is obtained which can be poured into moulds. The process is applied for making not only sanitary ware and terra-cotta goods, but also dishes, crucibles and laggings of fireclay, and other refractory products; for instance, the pots in which glass is melted. The diagrams of the machinery which were shown were very simple. The materials were delivered by an elevator into a mixing-machine and then into stirrers, from which the pasty substance was run into molds.—(Lond. *Engineering*, June 11.)

Rubber.—Meyer Wildermann described a technical process for the improvement of low- and medium-grade rubbers. Such rubbers may contain a fair proportion of good rubber; but a comparatively small percentage of resin in the rubber depreciates the product very badly. The reasons are that the resins are unstable and liable to oxidation, that their presence prevents correct vulcanization, and that the resinous rubbers are sticky and cannot bear the vulcanization temperature without running, and have to be mixed with all sorts of ingredients to allow of some vulcanization. Several former processes for extracting the resin were discussed. The process which the author proposed is cyclic and does not aim at separating the whole of the rubber from the whole of the resin. He prepares a series of mixtures of two solvents—say, chloroform and alcohol; the first dissolves only rubber, the second only resin. In applying the process mixtures rich in chloroform are gradually replaced by mixtures in which alcohol predominates; the solution is drained off and the solvent recovered, first, under atmospheric pressure, then in a vacuum, and fresh mixtures are prepared and re-used. Such an extraction takes only 12 hours, and much less solvents than former processes. The valuable rubber remains undissolved and unimpaired, and the resulting product is more uniform than with other treatments.—(London *Engineering*, June 4.)

"Thermic Reactions in Vacuo."—Frank E. Weston and H. Russell Ellis call "thermic reactions" that general class of reactions of which the Goldschmidt thermit reaction is the most celebrated example and which are distinguished by a great evolution of heat and by the necessity of having a certain amount of heat energy imparted before reaction proceeds. Other thermic reactions are the reduction of oxides and sulphides by Ca and of CaO by CaH_2 (F. M. Perkin), the reaction AMg_3Ca_1 and Al upon MgO, Al_2O_3 and CaO, etc. The

initial energy necessary for starting the reaction can be supplied in different ways. In many reactions the presence of air has a very great influence over the course of the reaction and on the nature of the products; many reactions can be arrested by the exclusion of air and restarted by exposure to air. An initial high temperature is required to start all thermic reactions, and when two oxides are being studied the heats of formation of which are close external heat must be supplied to change the oxygen from one metal to the other. This heat can be obtained from an external source or from the combustion of the reducing agent with the oxygen or nitrogen of the air or both. With a view to ascertaining what part the atmosphere plays, attempts have been made to carry out such reactions in vacuo. They had difficulties in starting such reactions when air was excluded, the various reactions taking place with vigor when air was present. The various mixtures were heated in vacuo by glowing platinum wires up to the melting point of platinum, by iron wires and by igniting a fuse of $4Al + 3Na_2O_2$, but very few reactions took place, and many which started only continued for a short while. The reactions between Al_2 and Fe_2O_3, $4Al + 3Na_2O_2$, $2Mg + Na_2O_2$, $Mg + Na_2O_2$, $3Mg + Na_2O_2$, $Al_2O_3 + 3Mg$, $Mg + SiO_2$, $2Mg + SiO_2$, have all been brought about in vacuo, but always more quickly than in the open air and with different products. A very large number of other mixtures have been tried, but up to the present without success, the difficulty being to produce a great initial "heat density" without which, air being excluded, action will not take place. The work is being continued, and the various mixtures heated before firing the fuse, etc.—(From advance sheets.)

Nickel Bronzes as Anti-Friction Metals.—R. Adan, of Gand, Belgium, presented a paper on "The Utilization of Nickel-Bronze as Anti-Friction Metals." The abstract did not give any anlysis, unfortunately, but the author stated that bronzes prepared from fresh metals proved far inferior to bronzes made from scrap, probably because in the latter case the metals were in a finer state of subdivision. The specimens were fused three times and then submitted to tension tests, impact tests on Guillery-Frémont machines and Brinell tests. The bronzes took a high polish, resisted the action of alkalies and diluted acids, and were recommended for stuffing boxes, valves, collars, etc.—(London *Engineering*, June 11.)

Aluminium Plating.—E. C. Szarvasy presented an interesting communication on the corroding of aluminium in alcohol. Incidentally, a method has been developed for plating aluminium, which up to now has been an unsolved problem. The bath employed is a solution of a dry copper, nickel or tin salt in anhydrous methyl alcohol. The aluminium to be plated is thoroughly cleaned with a metal polish containing fats. The object of the fat is to protect the clean metal surface from atmospheric oxidation. The metal is then introduced into the bath, the alcohol dissolves the fat, and copper, nickel or tin is deposited in an adherent form on the aluminium surface.—London *Electrical Review*, June 11.)

Thermal Treatment of Non-Ferrous Metals and Steel.—Two papers on "The Thermal Treatment of Non-Ferrous Metals" were read by L. Guillet; the authors were A. Portevin and L. Guillet. Portevin dealt with alloys of copper, bronzes of copper-tin and of copper-aluminium and the influence of tempering and annealing, considering also the influence of the thickness of the specimens. In brasses the annealing process could, he said, be followed with the aid of metallographic analysis and of Brinell hardness tests. For copper alloys, Portevin concluded, the conditions of melting, the temperature and time of heating and cooling, the rate of cooling, and the disposition of the constituents in the molds had greater influence upon the properties of the alloys than had been attributed to them, and the regulation of these factors enabled us to secure effects which had otherwise been obtained only by the addition of foreign metals. Guillet, in the communication already mentioned, as well as in a further paper on "The Thermal Treatment of Steels," comprising special steels, likewise accentuated the importance of the time-factor. The same blue tint was, he said, obtained by heating for 10 minutes (always in the air) up to 350° C., or for 30 minutes to 300°, or for four hours to 250° C.—(London *Engineering*, June 11.)

Ferro-Alloys.—M. Chaplet referred to the progress made in the production of ferro-alloys low in carbon and to the great value of these in the iron and steel foundries. M. Chaplet pointed out that the carbon in these ferro-alloys was generally present in the form of a double carbide of the iron and the rarer metal, and that in many cases these double carbides would be found in the form of isolated grains, and would become centers of pitting and corrosion in the finished steel. This was found to be especially the case with Martin steel deoxidized with ferro-manganese carbide. The author then referred to the Chaplet furnace in which ferro-alloys are now produced at Allevard-Giffre. This is an electric furnace of a modified form in which the use of a carbon base or "sole" has been dispensed with, in order to diminish the percentage of carbon in the finished alloy. The author also pointed out the advantages of selecting a deoxidizing agent which would yield a very fluid slag at the temperature of the metal to which it was being added, and named the ternary alloys, containing silicon, as the most valuable in this respect.—(*The Engineer*, London, June 11.)

Recording Calorimeter.—C. V. Drysdale described a recording calorimeter with the following essential details of structure: A thermopile is constructed of strips of iron and of constantan, each of which forms two sides of a rectangle, and is riveted and hard-soldered to the next element. The result is a rectangular spiral of 15 elements with one set of junctions at the top, and the other set at the bottom. Insulating strips of mica are inserted along the vertical sides of the spiral, which is clamped between two asbestos boards by means of metal frames. The whole arrangement thus forms a lamp chimney. The flow of air takes place between the strips at the bottom and the top where the mica insulation is absent. In operation cold air enters at the bottom, passing through the cold junctions to a combustion jet. The hot products of the flame then traverse the interstices between the top strips, and the e.m.f. developed by the pile indicates the rise of temperature resulting from combustion. The resistance of the pile is low, and the power produced is sufficient to obtain a trace on a recording instrument. The galvanometer is a very robust double-pivoted instrument, the pointer of which carries the recording pen. The results obtained are uniformly good.—(London *Electrical Review*, June 11.)

Smelter Smoke Troubles.—Charles Baskerville discussed the legal status of industries giving rise to noxious gases and the smelter smoke question in the United States. He gives a review of the American laws regulating the pollution of the air with noxious or offensive gases, with a discussion of the cases in point of rule, general decisions, and the remedies proposed for the suppression of such nuisances. It is shown that there is neither entire uniformity nor definiteness of statement in the codes of the several States, and that no specific regulations obtain. After a discussion of the foreign laws on the subject, the solution of the "smelter smoke question" is considered. It is pointed out that considerable progress has been made by some manufacturers toward the installation of waste recovering devices, and that the enforced use of such contrivances by the enactment of a Federal law regulating the amounts of waste gases to be permitted to pass into the air will alone solve this great national industrial problem. However, the geographical and meteorological conditions prevailing in the various States must be carefully considered. The paper is replete with legal citations.—(From advance sheet of paper.)

Cryolite.—C. F. Jarl explained the meaning of cryolite and its uses for the production of opalescent glass, and as a constituent of leadless glass, in addition to its use as a solvent of alumina.

RECENT METALLURGICAL AND ELECTROCHEMICAL PATENTS.

In view of the extensive convention and congress reports in our last and in our present issue, a large number of abstracts of both metallurgical and electrochemical patents must be held over for our next issue, in which our records of these departments will be brought up to date.

Steel for Armorplates.—The cementation of armorplates has resulted in considerably increasing the resistance to uncapped projectiles, in comparison with the homogeneous armorplates previously employed. But when attacked by capped projectiles, they offer but a relatively small resistance and one which is far from uniform. Eugene Schneider, of Le Creusot, France, patents an alloy steel, and claims that homogeneous armorplates made from this steel present a more uniform resistance to the attack of uncapped projectiles, and that they also offer greater resistance to capped projectiles than the best armorplates heretofore known. This steel contains "in addition to the iron, per hundred parts, 0.30 to 0.50 carbon, less than 0.350 manganese, 3 to 5 nickel, 0.5 to 1.5 chromium, and while the metal is in fusion, from 0.5 to 1.5 per cent of molybdenum or 1 to 3 per cent of tungsten, or again, 0.2 to 0.5 per cent of vanadium are added. The presence of the molybdenum, tungsten or vanadium separately or combined in twos or all three added together to the nickel and chromium in the steel, advantageously replaces the high percentage of carbon in the impact face of cemented armor plates, because it makes it possible by any convenient process of tempering to obtain in regard to this face a hardness sufficient to crush the projectiles and preserve all the desirable malleability in the metallic mass for avoiding cracking on firing." (925,659, June 22.)

Electric Steel Refining.—O. Thallner, of Bismarckhutte, Germany, who has made a special study of steel refining in the Héroult furnace (our Vol. VI, page 26), proposes the following combination process. Steel previously refined in a Martin, Bessemer or Thomas furnace, is first treated in an electric furnace provided with a basic lining, such as lime. In this furnace the refining is pushed so far that the metal is perfectly free from carbon, manganese, silicon, phosphorus and sulphur. In this condition the metal contains not only considerable quantities of oxygen in the form of oxides, but it possesses also the capability of taking up oxygen when coming in contact with the air during pouring. This unfavorable property can be avoided by carrying out the last stage of the process in an acid-lined electric furnace. This stage comprises removal of the oxides contained in the bath owing to the action of the acid hearth and then carbonization. Also the addition of alloys can take place in the acid-lined electric furnace much more favorably than in a basic-lined furnace. Such addition may be, for example, silicon, chromium, tungsten or nickel. By means of this combination it is possible to produce a product which possesses a perfectly compact structure with only the smallest possible content of manganese and carbon or with practically none of these constituents. (925,612, June 22, 1909.)

Lash Steel Process.—With respect to the Lash process which has been covered very fully in our columns (see, for instance, our last issue, page 268), two recent patents granted to Mr. Horace W. Lash are of interest. In one of them it is stated that the use of solid or molten pig iron in the lower part of the charge is of the greatest advantage in practical operation. The first claim refers to "a process of smelting iron oxide which involves charging into a furnace a smelting mixture containing finely divided oxide of iron, finely divided cast-iron and carbonaceous material, and also disposing in said furnace a quantity of pig metal in proper manner to form a bath beneath the smelting mixture and applying a smelting heat to the charge. (924,677, June 15, 1909.)

Mr. Lash's second similar patent refers to the application of the electric furnace to his process. A suitable smelting mixture may consist of 54 per cent oxide of iron (ore), 27 per cent cast-iron borings (or granulated pig iron), 8 per cent crushed coke, 4 per cent coal-tar pitch, 4 per cent sawdust, and 3 per cent crushed limestone. This mixture is made up into briquets with the aid of the coal-tar pitch as binder. The briquets or lumps are charged into an electric furnace. The sawdust disappears and leaves the mass porous. Then part of the coke and the metalloids and easily oxidizable metals contained in the finely divided cast-iron unit with the oxygen of the ore and reduce the ore to metallic iron. The fused iron collects on the bottom of the furnace; in view of the non-oxidizing atmosphere of the electric furnace it will be high in carbon and easily fusible. A portion of the bath is then tapped from the electric furnace into an adjacent gas-fired refining furnace. But part of the molten iron is left in the first electric furnace and a fresh supply of the above-described smelting mixture in form of lumps or briquets is added. "The furnace being already at a high temperature and the bath of retained metal containing oxidizable metalloids capable of aiding in reducing the iron oxide of the smelting mixture, it is found that within a short time the entire mixture is reduced and the heat again ready to be tapped, so that a portion of it may be run into an adjacent furnace for further treatment, while a portion of the bath is again retained in the furnace and the smelting operation is continued in the same manner as before. (924,676, June 15, 1909.)

Deposition of Metal on Porcelain and Earthenware.—Quentin Marino metallizes in the following way vitreous, porcelain, earthenware and similar surfaces so that metals can be electrolytically deposited upon them. The surface is first roughened or rendered matte, for instance, by means of hydrofluoric acid. A cold solution is then made by putting cuprous oxide into a solution of nitrate of silver, whereby a gray substance is quickly formed consisting of filiform silver and basic nitrate of copper

$$6\,Ag + 2\,Cu\,(NO_3)_2 + Cu_4O_3\,(NO_3)_2.$$

This gray substance is then dissolved into hydrofluoric acid, and the solution so formed is applied, say, by means of a brush, to the roughened surface. In order to insure its adherence, the inventor reduces the copper and the silver in the fluoride to the metallic state. For this purpose he dusts the surface, while it is wet, with the last-mentioned solution, with a mixture of metals, or with one metal only, in a finely divided state so as to reduce the silver on the one hand and the copper on the other, both of which latter are combined with the fluoric acid. A mixture of powdered copper and zinc may be used, or a powder of copper with either iron, nickel, cobalt, cadmium, lead or bismuth, the copper and zinc reducing the silver, while the zinc, iron, nickel, cobalt, cadmium, lead or bismuth reduce the copper. Or powdered zinc may be used alone, as it reduces both the silver and the copper. The surface thus becomes coated with a mixture of silver and copper in the form of a very thin film sufficiently continuous to be electrically conducting for the purpose of receiving an electroplating deposit. Before starting electrodeposition it is preferable to rube the surface briskly when dry, with a brush or the like, so as to polish it. (935,365, June 15, 1909.)

Tantalum.—According to Werner von Bolton, the pioneer of the metallurgy of pure tantalum and of the tantalum lamp, tantalum can be hardened by additions of 1 to 10 per cent of silicon. By adding 2 or 3 per cent of silicon, for instance, a material of great ductility and considerable hardness is obtained. (925,988, June 22.)

Fixation of Atmospheric Nitrogen.—Demetrio Helbig produces a long arc for the purpose of oxidizing atmospheric nitrogen. Compressed air is projected by two opposite nozzles arranged in line, against an arc between suitable electrodes, whereby two sheaves of flame are produced spreading out along the electrodes in a plane normal to the direction of the nozzles. A modification for three-phase currents, producing a flame-disk, is also described. (926,413, June 29.)

High-Pressure Oxy-Acetylene Welding.

BY HENRY CAVE.

It is not generally known in this country that three distinct types of oxy-acetylene torches were developed in France. These are distinguished mainly by the different pressures under which the acetylene is used, being termed, respectively, low, medium and high pressure.

The low-pressure torch, which uses acetylene at not over 2-lb. pressure, and often much less, is well known in this country; but as the high-pressure torch—which uses an equal pressure of both oxygen and acetylene, which may be as high as 25 lb. per square inch, necessitating the use of dissolved acetylene in cylinders—was never introduced into this country, what in

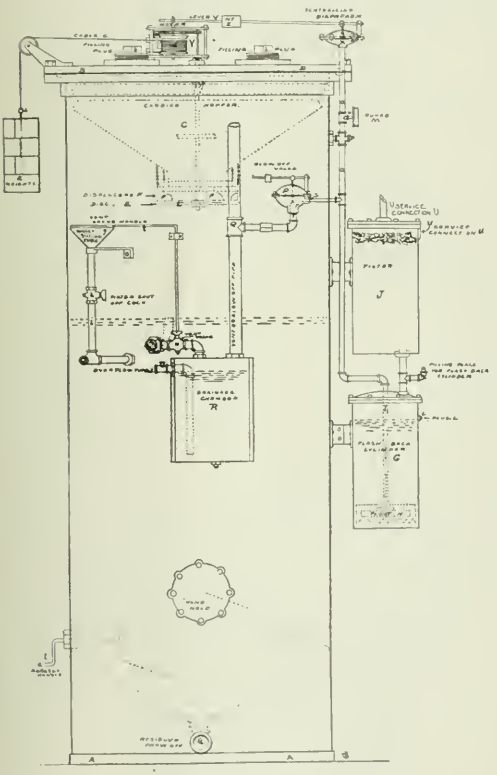


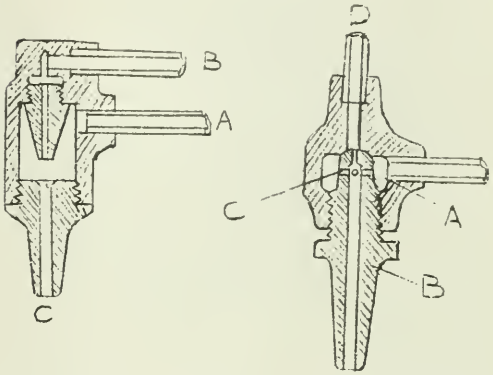
FIG. 1.—OXY-ACETYLENE WELDING SYSTEM.

France is termed the medium-pressure torch, using acetylene from a generator, as shown in Fig. 1, at pressures up to 10 lb. per square inch, is known here as the high-pressure system.

In an article entitled "A Comparison Between Welding Systems," which appeared in the May issue of this publication, it was stated in reference to the high- and low-pressure torches "of the two systems the low-pressure system of welding has undoubtedly been most generally adopted and is now gradually superseding the older system." The author of this article must have had the real French high-pressure system in mind, as both in France and in this country the high- (medium) pressure system is rapidly superseding all others, even to the extent of replacing existing low-pressure equipments. There are more makers of the low-pressure equipment due to the fact that there are very few patent restrictions, and these have not been defended. The high- (medium) pressure system, however, is well protected.

There are probably more small users of the low-pressure equipment, as cheap equipments are on the market, but practically all the large users have installed the high pressure owing to the economy of operation and stronger welds produced.

This is shown by the attitude of the United States Navy Department, who installed the high-pressure equipment after ex-



FIGS. 2 AND 3.—LOW-PRESSURE AND HIGH-PRESSURE TORCH.

haustive tests of all kinds, and have placed several duplicate orders since the first plant was placed in operation.

When one compares the methods of mixing the gases in the torches of the two systems, the reason of the economy and efficiency of the high-pressure system is obvious.

The low-pressure torch operates on the well-known injector principle, the general idea being shown in the diagram, Fig. 2, in which the acetylene comes in at *A* under no appreciable pressure, the oxygen supply passing through *B*. It can be readily seen that the force of the oxygen under considerable pressure will draw a certain proportion of acetylene along with it out through the nozzle *C*, where it burns.

But the mixture thus produced is not homogeneous, the gases being stratified. This causes a ratio of 1.80 of oxygen to 1.0 of acetylene to be required to give the correct flame, whereas the high-pressure torch only requires 1.28 of oxygen to 1.0 of acetylene to give the same flame. This is due to the close and intimate mixture of the gases obtained by the two gases striking together at right angles, both under appreciable pressure.

The means by which this is carried out can be seen in the section of the high-pressure torch, shown in Fig. 3. The acetylene passes through the flash-back chamber in the handle and through the large tube into the annular space *A* around the detachable tip *B*, which it enters through the small radial holes *C*.

FIGS. 4 AND 5.—EXAMPLES OF WELDS

The oxygen passes through the small pipe *D* into the detachable tip through a hole in the end, strikes the four incoming jets of acetylene at right angles, and thus produces the homogeneous mixture before spoken of, not only resulting in a saving

of oxygen of nearly 40 per cent, but owing to the reduced oxidation of the metal, giving a much stronger weld and materially increasing the elongation.

Owing to the fact that the amount of acetylene passing into the tip is positively regulated by the four radial holes a correct mixture is produced under all conditions. This is not the case

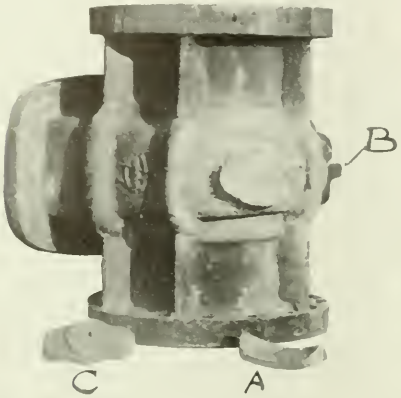


FIG. 6.—PIECE TO BE REPAIRED.

with the injector type of torch, owing to the fact that the amount of acetylene drawn in varies as the square of the velocity of the oxygen, and this may be changed by the expansion of the nozzle, or by particles of metal adhering to it. The operator has, therefore, to keep constant watch on the condition of the flame or bad welds will result.

Unfortunately those in charge of plants in this country know very little of the possibilities of this process, and therefore the general introduction of the tool (for such it really is) into this country is very slow, and this is helped very little by the majority of the technical articles which appear from time to time, as they deal mainly with the equipments on the market or with comparative strengths of welds, instead of describing and illustrating work that has actually been carried out successfully, which is far the best way to impress those likely to have use for the system.

The publication of comparative strengths of welds is, of course, useful, but often very deceiving, as the tests frequently compare the strength of welds with that of the original material which has often had a mechanical strength imparted to it by rolling, which is, of course, removed by heat irrespective of whether the part has been welded together or only heated.

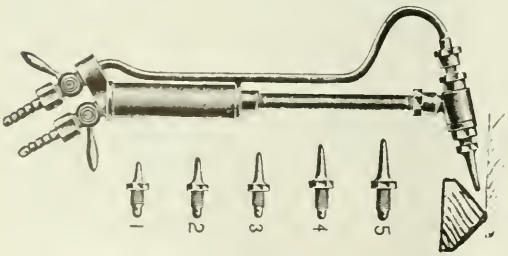


FIG. 7.—REPAIR WITH TORCH.

To get a correct comparison of the actual weld it would be fair to give both the welded and the original piece the same heat treatment. A short time ago an article was published giving the strength of the seam of kitchen boilers welded by electricity and by the oxy-acetylene process which showed unfavorably for the latter. But the tests were based on electric welds made in a large and expensive machine specially constructed for the purpose, whereas those made by the oxy-acetylene torch were the result of a few experiments by hand, so that neither the cost nor strength showed favorably.

It would, of course, be possible to rig up to do this work by the oxy-acetylene process in a machine so that much better results could be obtained.

A good idea of the strength of a steel weld is obtained by the piece shown in Fig. 4, which shows two pieces (1½ in. x

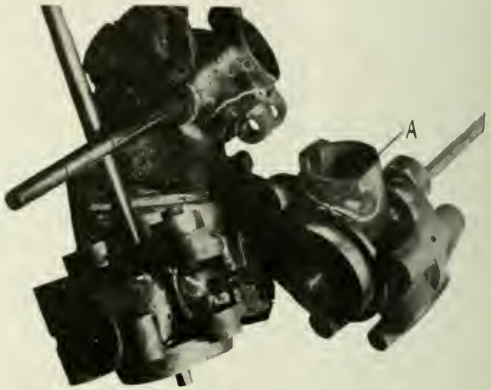


FIG. 8.—REPAIR OF AIR-HOIST CYLINDERS.

5/16 in.) welded together and then hammered out cold until cracked. As can be seen, the crack first occurred away from the weld, the piece being increased in width ¾ in.

Very little has been said of the strength of cast-iron welds, but these show up favorably, as can be seen in Fig. 5, which shows a test piece which broke at a flaw in the weld under a tensile strain of 25,000 lb. per square inch, which is very close to the maximum strength obtainable in ordinary gray iron.

For repairs, which form by far the largest field for the process at the present time, the strength of the weld per square inch does not often count for a great deal, as in the majority of cases

FIG. 9.—WELD OF BRONZE PINION.

metal can be built up over the weld so as to remove all possible doubt of its holding, even if the strength per square inch is much less than the original metal.

This is well illustrated in Fig. 6, which shows a 10-in. gate-valve body made from a steel casting which, after being machined up, was found by the Chapman Valve Company, of Indian Orchard, to be short of a boss. The steel foundry had failed to make use of the loose piece on the pattern provided for this purpose. As it was necessary to find some way out of the difficulty, the problem was solved by sending the castings

to the Autogenous Welding Equipment Company, Springfield, Mass.

They had the steel forging, shown at *A*, Fig. 6, made so as to form as large a part of the boss as possible. The flame of the oxyacetylene torch is very small, the tip used for this purpose giving a welding flame that is only about ⅜ in. long and ¼ in. in diameter. It is, therefore, necessary that the flame should come in contact with every drop of metal welded, it not being possible to make a lap weld. Thus it was necessary to make the forging *A* V-shaped, so that it would form a groove when placed against the wall of the casting to allow the flame to reach to the center, as is shown in Fig. 7.

FIG. 10.—REPAIR OF TRANSMISSION CASE.

It was first of all necessary to cut off a lug corresponding to the one shown at *B*, with the cutting torch. This lug was put on the pattern for the purpose of locating the loose piece which is shown at *C*. The forging was then held in position and the torch applied, metal being added from a low-carbon steel wire to fill up the groove and build up the required shape.

FIG. 11.—EXAMPLE OF STEEL PLATE WELD.

The boss was then faced up and showed good, sound metal. It can be readily realized from this job what a boon this equipment will prove to the machine shop, as everyone knows the uncertainty of obtaining sound steel castings, and all these defects can be satisfactorily taken care of with the oxy-acetylene torch.

The repairs to the air-hoist cylinders, shown in Fig. 8, give a good idea of what can be accomplished in this line with cast iron. The chalk marks show where the welds occurred, and the parts shown at *A* being missing, a new piece was made up and welded in. The saving in this case alone would represent a pretty good rate of interest on the investment in installing an equipment.

Fig. 9 shows a weld in a bronze pinion 5 in. in diameter, the tooth marked *A* having been broken out by the pressure of the key.

Fig. 10 shows the upper and lower parts of a transmission case which were welded in 14 different places, including a lug welded on at *A*. Even though these parts were so badly damaged, the cost of the work made a considerable saving over a new case.

What can be accomplished with plate steel is well illustrated in Fig. 11, which shows a gear cover made completely of steel, the bosses and brackets being welded on; and those who have had trouble with the breaking of the light cast-iron ones usually supplied will appreciate this improvement.

The photographs are from work carried out by the Autogenous Welding Equipment Company, Springfield, Mass., with their Davis-Bournonville high- (medium) pressure torch.

Recording Thermo-Electric Pyrometer.

A new electric recording pyrometer, distinguished by simplicity of operation and construction, has been recently designed by Messrs. Edward Brown & Son, of Philadelphia, Pa. While the recording device is specially constructed for use in conjunction with a thermo-couple as a thermo-electric recording pyrometer, this type of recording gage could be used for very accurately recording pressures of steam and blast, volts, etc.

As a pyrometer, the complete equipment consists of a thermo-couple of two nickel-alloy rods suitably insulated and protected, the recording electric pyrometer, and the leads or wire for connecting the thermo-couple and the recorder. The leads are commonly of any length from 100 ft. to 500 ft., and very frequently the same thermo-couple which generates the current for the recorder also actuates an indicating instrument on the same circuit, but located near the furnace for the operator's assistance.

FIG. 1 —DRAWER (WITH CHART AND CLOCK MECHANISM) WITH DRAWN ON THE LEFT.

The electric recording pyrometer gage consists of a milli-voltmeter system carrying a small drop of ink on the pointer or needle. As this milli-volt-meter system is in a horizontal position there is no change in weight or position of the pointer with an increase or decrease of ink. A large 8-in. chart of stiff white paper is raised once a minute by a powerful eight-day clock and touches the ink pen, making a small dot on the

FIG. 2.—RECORDING PYROMETER.

chart. These continuous dots form into a fine line, and as the pen is only in contact with the chart a very short time, the pointer is able to fluctuate readily with the rise and fall in temperature. This momentary contact with the paper is necessary in an electric pyrometer, as the milli-voltmeter system has not enough power to pass across a paper in which it was in constant contact.

In order that the chart may be readily removed from the instrument without the danger of striking the pointer or necessitating the moving of the system, the chart and clock mechanism are carried on a drawer which can be withdrawn. This drawer is carried on ways or guides, causing the drawer to be lowered as it is drawn out and preventing the pointer dragging a line across the chart. The drawer can either be withdrawn part way, or can be withdrawn entirely and the chart removed and a fresh one placed in position. It is a much

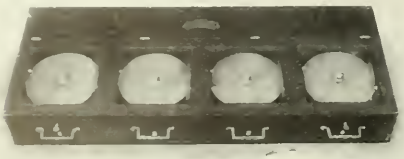


FIG. 3.—QUADRUPLE PYROMETER FOR FOUR FURNACES.

simpler matter to change the charts on a recording pyrometer when lying on a table or shelf than in the recording case.

Once a day when changing charts, a drop of ink is placed in the recording pen with a dropper or pointed article. Occasionally also it is desirable to pass a camel's-hair brush, dampened with water, through the recording pen in order to clean the pen and insure a fine ink line. To enable this to be easily attended to, a frame is raised from the base of the recording instrument as the drawer is withdrawn and forms a rest for the pen-pointer. Although the parts of the recording instrument are well protected by the case, the milli-voltmeter and the clock mechanism are both enclosed in metal cases as an additional protection from dust.

Where it is desirable to record the temperature of several furnaces, these recorders can be supplied for two or four furnaces, all records being made in one case.

The recording electric pyrometer can be supplied by the manufacturers for any desired range in temperature, and the record charts can be made to revolve once in 24 hours or 7 days, if preferred.

The last diagram shows a greatly reduced record chart printed in one color only. This chart shows the form of dotted red line made by the Brown recorder and incidentally shows that the fireman attending this furnace was now "on the job" for several hours during the night, and the temperature in consequence dropped rapidly.

The Brown electric recording pyrometer has already been

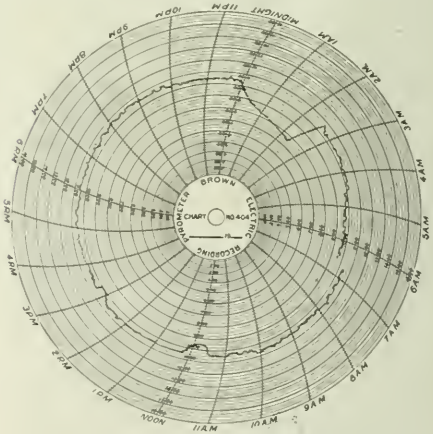


FIG. 4.—RECORD CHART.

supplied for use at a number of blast furnaces and for annealing ovens, glass-melting furnaces, brick kilns, and other operations where a clear record of the temperature is desirable.

Fuel Engineering.

Largely through force of circumstances the engineer rather than the chemist has been looked to as the expert in consideration of efficiency of fuel. But the broad field of fuel engineering must include mine inspection, expert knowledge of methods of preparation, inspection, sampling and testing of coal, power-house practice, smoke abatement, the design of power plants, gas-producer practice, and acquaintance with the manufacture of illuminating gas. In a word, the knowledge required is a combination of that independently possessed by the mechanical engineer, the chemical engineer and the mining engineer. As it is practically impossible that a single individual should possess such a diversity of knowledge, it is evident that the best results will be obtained by the co-operative work of a number of experts, each trained and experienced in his particular branch of the work. But such opportunity for co-operation is only warranted in a large and fully equipped organization.

In this connection, and as indicative of the trend in fuel engineering, it is interesting to note that Mr. Arthur D. Litttle, Boston, Mass., has recently perfected such an organization in connection with his laboratory of engineering chemistry. The

staff includes as its chief a mechanical engineer and as principal assistants a chemical engineer and a mining engineer. All of these individuals have had extended experience, including connection with the fuel-testing plants of the United States Geological Survey. Three other assistants on the chemical side of the work have had similar, though less extended experience in connection with the testing and use of fuels.

New Revolving Stand for Electrolytic Analysis.

The work of Dr. Edgar F. Smith and others has demonstrated the great saving of time in electrolytic analysis that may be accomplished by using a rapidly revolving platinum disk as an electrode. The mechanical arrangements are, however, rather cumbersome and expensive. To overcome these objections, Mr. C. J. Reed, Twenty-third and Hamilton Streets, Philadelphia, has brought out an apparatus which is very simple and inexpensive, doing away with the necessity of a separate motor and belt. The complete apparatus is shown in operation in Fig. 1 and ready for operation in Fig. 2. The various parts unassembled are shown in Fig. 3.

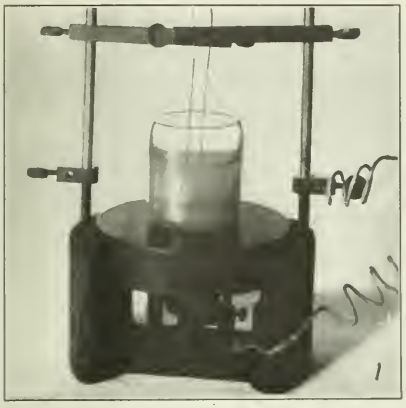


FIG. 1. REVOLVING STAND FOR ELECTRO-ANALYSIS IN OPERATION.

The apparatus consists of a platform revolving on a vertical shaft, the platform itself being the armature of a motor. The beaker containing the solution to be electrolyzed is centered automatically on a floating disk, which rests on and covers the platform. Electrodes of any form and material may be used. Contact with a mercury electrode may be made through a wire passing through the glass beaker or through a platinum wire sealed into a glass tube and inserted from above. The speed is adjustable through a wide range (10 to 1000) by turning a thumb-screw. The motor consumes only from 3 to 5 watts and may be operated by the same current used in the electrolysis or by any separate source. In Fig. 1 the current used in electrolysis also operated the motor in series with the cell.

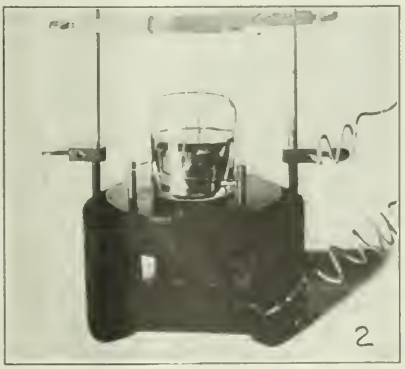


FIG. 2. APPARATUS READY FOR OPERATION.

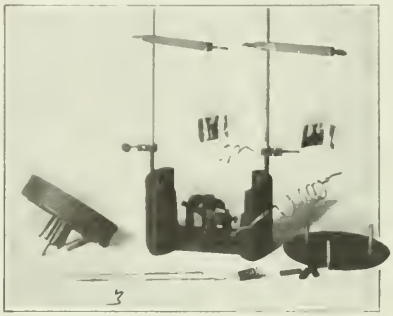


FIG. 3. VARIOUS PARTS OF APPARATUS

Tinol, a New Solder.

While the process of autogenous welding by means of the oxy-acetylene blowpipe, or by the thermit reaction, is forging ahead in a very encouraging manner, the time-honored art of soldering is not standing still, as will be seen from the following description of tinol, a new solder which originated in Germany and is now being introduced by the American Tinol Company, 2100 Fairmount Avenue, Philadelphia, Pa.

Autogenous welding means to make a joint directly out of the two surfaces to be joined together, without any foreign material, whereas the characteristic feature of soldering is the use of a foreign material in the solder. While both operations are thus fundamentally different, some principles are the same, the most important one being the necessity to prevent oxidation while making the joint. In soldering this is done by means of a flux which prevents direct contact of the joint with the air.

Until recently the practice was to moisten the carefully cleaned joint with some acid flux, and then flow melted solder (lead-tin alloy) along the joint by means of a heated and tinned soldering iron or copper. If the acid was not carefully neutralized after the joint was completed, a slight remaining excess was certain to corrode the joint and this in some cases proved disastrous. To overcome this, powdered rosin was substituted for the acid flux; while this cured the danger of acid corrosion, the difficulty of making a good joint was greater and the work was apt to be sticky, and not as neat.

As is well known to every metal worker, all alloys of lead and tin, on melting in contact with air, form oxides or dross. The presence of such oxides prevents metallic union of the solder with the metal to be joined. The so called fluxes serve to protect the melting solder against direct contact with the air and hence against such oxidation.

Tinol is a new solder. It is sold in form of a finely granulated solder, each grain coated with a fatty organic substance which is neither acid nor alkaline. This coating or flux begins to melt before the solder, but is not completely evaporated until the solder has set; it thus protects the solder fully against oxidation during the entire operation.

Practice has shown that when using tinol solder with such materials as tin, lead, brass, and copper, no special cleaning as

by scraping or dipping is necessary; if the joints look clean to the eye, that will be sufficient. Iron and steel must be cleaned of rust and scale.

The mixture of granulated solder and fatty flux forms a paste called "tinol paste." It is of a consistency that allows easy application by a knife blade, glazier's spatula, stiff bristle brush, or even with the fingers. The paste is marketed in tin cans.

The essential feature is that this tinol paste is applied cold to the cold joint. This has various practical advantages. For instance, if a number of joints, for instance in a cable, are to be made, they are first made cold by a brush or knife, and then the joints are finished by quickly passing from joint to joint with the heating torch. Or internal heating may be employed by passing a sufficiently strong electric current through the cable to melt the solder and finish the different joints. Whenever this method is applicable, it gives particularly good results, due to the heat passing from the inside to the outside.

As tinol paste is applied to the cold joint, the awkward handling, resulting from the need of holding the wire (frequently necessary in confined places) and at the same time applying the solder and heat, is avoided; a helper is, therefore, never needed, and the work even in confined quarters is rendered easy.

Droppings, which with ordinary solder are practically unavoidable, are absent with tinol, since experience soon teaches just how much paste to apply in the cold state to insure the filling of the joint and no more.

As it is convenient for some work to use solder in stick and in wire form, tinol is made up also in rods and wires of different sizes, ranging from 5/6 in. down to 1/32 in. These rods and wires are all hollow and contain the same flux used in the tinol paste.

Any source of heat may be utilized, as a gasoline or alcohol torch, hot poker, the usual copper, etc. For light work an ordinary wax match will answer. One advantage of the fine granulation of the solder is that much less heat is needed than with bar solder, since each grain melts more readily.

The German postoffice, in comparative tests at Hamburg on making joints on telegraph wires, found that by the use of tinol the quantity of solder required and the average time of making a joint was very considerably reduced. Resistance tests showed that the conductivity of tinol joints is as high as that of the wire itself.

Broad surfaces can also easily be joined by means of tinol solder. Brushing the paste onto broad surfaces, bringing these together under the requisite pressure and heating in gas furnaces has given very good results for quantity work. For smaller quantities pressing between heated tongs is a neat and effective method.

For narrow joints in sheet metal work the paste is applied to the edge of the joint and then heated in any convenient way, by torch, soldering iron, etc.

For wider joints, the paste is thinned down with a little water and applied with a stiff bristle brush. This is then heated with a torch, or otherwise, as may be convenient, until the metal glistens; in this way the entire surface of the joint is at one operation thinly and uniformly coated with clean tin. A second application of paste is then made, and the parts laid together under pressure and heated. A perfect union of the entire surface is the result.

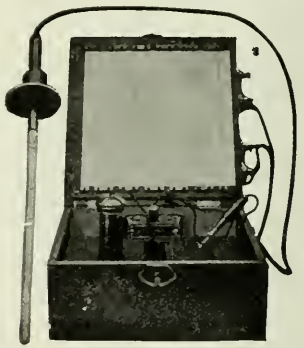
It is easy in this way to get perfect joints of several inches in width between thin and thick brass, copper, iron, steel galvanized metal, nickel-plated metal, lead, etc. Nor need the metals to be joined be similar; perfect joints between any dissimilar metals of those mentioned are readily made.

Absolutely tight connections for piping are made by smearing the threads with paste, screwing together, lightly heating and then screwing up solid while hot. This use in the pipe work led to its application as a nut lock. A light covering of the screw threads with paste and heating with a torch while screwing home results in so intimate a union that the body of the bolt twists off before the nut comes loose; but when loosening is required, heating with a gasoline torch makes that easy.

The American Tinol Company, of Philadelphia, introduces tinol in the shape of tinol paste, tinol rods, and tinol wire, and varying degrees of softness, the proportions of tin and lead varying between 100 per cent tin and 20 per cent tin to 80 per cent lead.

Electric Resistance Pyrometer Operated by Telephone.

While the thermo-electric pyrometer with its wide range of temperature (up to 1600° C., or about 2900° Fahr.) has found many useful applications in various industries, the electric resistance pyrometer, suitable for temperatures up to 1200° C, or about 2200° Fahr., also begins now to find much favor, especially in cases where a high degree of exactness is required. The chief endeavor of resistance-pyrometer designers has been



RESISTANCE PYROMETER OPERATED BY TELEPHONE.

in recent years to develop a thoroughly practical instrument, which can be readily operated in commercial work.

Messrs. Eimer & Amend, of New York, have just placed on the market an instrument of this kind. It is operated by telephone and is suitable for temperature measurements between 100° C. and 1200° C. (or about 212° Fahr to 2200° Fahr.).

The extreme delicacy of the telephone, combined with the direct-reading scale graduated either in Centigrade or Fahrenheit degrees, gives the instrument qualities which commend themselves at once to practical men. Being perfectly portable, with no adjustment to be made when placed in position, there is nothing to get out of order.

By means of a switchboard, any number of pyrometers may be connected to the same reading box, situated at any distance from the source of heat.

The instrument consists of two essential parts: the heating element and the indicator.

The heating element is a coil of fine platinum wire wound on a mica frame, the resistance varying with its temperature. This coil is connected to the pair of binding posts by heavier platinum wires, which are protected by a porcelain or silica tube. The latter also contains a second pair of heavy platinum wires coming from a second pair of binding posts and forming a loop which terminates at the junction of the other pair with the coil. These four wires are insulated or held apart from each other by passing them through holes punched in a series of mica disks, the whole fitting loosely into the protecting tube.

The second pair of leads, forming the loop, are provided as a means for the compensation of the platinum wire leads, and eliminate any effect due to proximity of exterior temperature or electrical influence in the wires connecting the heating element and the indicator.

The addition of these compensating leads also renders the indication of the heating element independent of the distance between the indicator and the source of heat.

The indicator has the form of a box with a scale calibrated in degrees Centigrade or Fahrenheit and a stylus or pointer, which can be moved along the scale wire. This box also contains two batteries and a switch and switch plug.

The operation is very simple. The heating element (the bulb containing the resistance wire) is placed at the point the temperature of which is to be measured. Connection is made to the four binding posts on the box. The switch plug is inserted on one or the other of the end holes of the switch, in order to connect one or the other of the batteries to the circuit. The pyrometer is now ready for making a measurement.

The stylus or pointer is slid along the scale wire, the telephone receiver being held to the ear, and the temperature is read off on the chart immediately below the point of the stylus on the scale when the ticking or humming noise in the receiver ceases.

A galvanometer may be substituted for the telephone receiver. In this case the pointer is slid along the scale wire until the galvanometer shows no deflection in either direction

This new pyrometer is one of the features of the new catalog of calorimeters and pyrometers just issued by Messrs Eimer & Amend, of New York, which contains a great amount of useful and valuable information.

Haanel Tablet.

A plate cast in iron, size 24 in. x 16½ in., and only ⅛ in. in thickness, has been received at the Mines Branch of the Department of Mines, Ottawa, Ontario, Canada.

This plate has been sent to Canada from Sweden, and bears in clear block letters, varying in height from 1 in. down to as small as ⅝ in., the following inscription:

"This plate was cast in honor of the visit of Dr. Eugene Haanel by the Atkiebolaget Elektrometall from iron produced by the Electric High Furnace at Domnarfvet, Sweden, Jan 1, 1909."

It is quite difficult to cast such a plate, yet this one is clear and free from the slightest imperfection or defect. The edges of the letters are sharp.

This plate proves conclusively that it is possible to cast difficult castings using iron taken direct from the Swedish electric furnace (described in our last issue), without remelting the iron in a foundry cupola.

Notes.

Bureau of Standards Analyzed Samples.—The Bureau of Standards in Washington, D. C., announces that it is ready to distribute an acid-open hearth steel with 0.6 carbon, and that a new sample of Bessemer 0.4 carbon is also ready in place of that hitherto supplied but now exhausted. The next samples to be issued will probably be basic open-hearth 0.4 carbon (renewal) and a straight vanadium steel with about 0.2 per cent V.

Society of Detroit Chemists.—At the annual meeting of the Society of Detroit Chemists, held on May 28, the following officers were elected: President, Frank T. F. Stephenson, Chemical Department, Detroit College of Medicine; vice-president, L. D. Vorce, Pennsylvania Salt Manufacturing Company; secretary, H. C. Hamilton, Parke, Davis & Co.; treasurer, W. D. Wainwaring, Railway Steel Spring Company. The membership reported is 84. Regular monthly meetings were held through the year, with an attendance of about 50 per meeting.

Infringement Suit.—The International Acheson Graphite Company, of Niagara Falls, N. Y., has commenced an action in the United States Circuit Court for the Western District of New York against the Castner Electrolytic Alkali Company of the same city, alleging infringement of its patents relative to its methods of making graphitized electrodes.

The Free Public Library, of Newark, N. J., informs us that the former reading room on the second floor of the library building has been converted into the "Technical and Scientific Department." The room is open on week days from 9 a. m. to 10 p. m., and on Sundays from 2 to 9 p. m. The department contains about 6,000 books and 300 periodicals on technical and scientific subjects, including chemistry, physics, electrical engineering, electroplating, etc. The United States, English and Canadian patent office reports, including United States patent specifications may be consulted. The books are not for reference only; most of them may be borrowed for home use.

Graphite Greases.—The new folder, 273 I, issued by the International Acheson Graphite Company, describes their graphited grease products which are designed for gears, cup and ball-bearing use. In the manufacture of their graphited grease, this company uses the world's purest and best graphite, which is a perfect lubricant in itself. The graphite and grease are beautifully blended, and it is claimed that the resultant product will do far more work than any other grease product on the market, great value being given the combination by the superior lubricating qualities of the graphite.

Bacteriological Apparatus.—In their new catalog of bacteriological apparatus, the Bausch & Lomb Optical Company, of Rochester, N. Y., have added another interesting publication to their long list. Aside from being very complete, the catalog is of interest since it describes a new electric incubator, made in various sizes, which presents a number of unique features. These incubators are run on the main current without any auxiliaries whatever, and, being self-contained, they require no more space than does the ordinary laboratory incubator. The many advantages attending the use of electrically heated incubators are too apparent to call for consideration here. Several forms of opsonic incubators, of hot-air sterilizers, steam-pressure sterilizers, and autoclave, afford a wide range of choice, while the water baths and paraffin ovens listed answer all laboratory requirements. In addition to these items, such accessories as thermo-regulators, thermometers and burners are given careful attention.

The Book Departments of the McGraw Publishing Company and the Hill Publishing Company have consolidated under the corporate name of the McGraw-Hill Book Company, with offices after July 1 at 239 W. 39th Street, New York. This consolidation brings together two of the most active publishers of technical books in the country. The new company takes over the book departments of both houses with a list of about 250 titles, both industrial and college text books, covering all lines of engineering. It will continue as well the retail, importing and jobbing business of the two houses. The officers of the new company are: President, John A. Hill; vice-president, James H. McGraw; treasurer, Edward Caldwell; secretary, Martin M. Foss. Mr. Hill is head of the Hill Publishing Company, which controls the *American Machinist, The Engineering and Mining Journal,* and *Power and the Engineer.* Mr. McGraw is head of the McGraw Publishing Company, which issues the *Electrical World,* the *Electric Railway Journal,* and *The Engineering Record.* Mr. Caldwell has been manager of the McGraw Book Department for several years, and Mr. Foss manager of the Hill Book Department.

Nitric Acid from Air.—In the fixation of atmospheric nitrogen by means of electric discharges, a comparatively dilute mixture of nitrogen oxide gases in air is produced and one of the troublesome problems is the cheap transformation of this dilute gas mixture into nitrates or nitric acid. A recent British patent of Sir William Ramsay (26,981, 1907; May 20, 1909) relates to this problem. It is summed up in the Lond. *Elec. Eng'ing* of May 27, as follows: "In the electrical manufacture of nitrates from atmospheric nitrogen the oxides of nitrogen present in the air that has been blown through the arc forms a trate and finally separate these oxides, the mixture is passed under pressure into a system of pipes surrounded by liquid air.

The mixture condenses and is caused to flow down a fractionating column and meet the products of evaporation of the liquid air. Rectification takes place, and nitrogen escapes from the top of the column. The oxygen and the oxides of nitrogen are returned to the tank containing the liquid, but the oxygen is continually evaporating. When the oxides of nitrogen are sufficiently concentrated in the tank, the liquid is run off and evaporated, the gases being passed through a solution to form nitric acid or a nitrate. The oxygen is passed with fresh air to the electric furnace, and increases the percentage of oxides produced. In a modified arrangement the different gaseous constituents are separated by fractional liquefaction."

Electric Furnace Iron Ore Reduction in Sweden.—With respect to electric furnace plants for iron ore reduction, which was described and illustrated in the paper by Dr. Haanel in our last issue, we have received, through the courtesy of Mr. Louis Simpson, the following additional information: "The reduction furnace erected by the Aktiebolaget Elektrometall, at Dennarfort, Sweden, still continues to give every satisfaction. There are no indications of a possibility of excessive repairs. The output exceeds 3000 kg of pig iron per hp-year, and the consumption of carbon is less than 300 kg per 1000 kg of pig. Director Yugstrom, of the Iron works, read a paper lately at a meeting of the 'Jerukontoret,' at Stockholm, in which will be expressed his satisfaction with the results. The success of this high reduction furnace is, therefore, indisputable. The new two-phase steel furnace lately erected at Hagfors has been started. This furnace, for the refining of metal and the making of steel, is also reported to be a success. A new company to reduce iron ore is now being started, called the 'A. B Trilhattans Elektriska Smaltverk.' This company will reduce iron ore and produce pig iron for iron foundries. The plant will consist of three reduction furnaces of 2500 hp each, making up-to-date arrangements for a final total construction of nine furnaces of 2500 hp each and one furnace of 1000 hp, or a total of 21,000 hp. As the first furnace of this type was only started late last year it can be claimed that no other electrical furnace has such a record." (See also a letter in our Correspondence columns in this issue.)

NEW BOOKS.

Ostwald Wilhelm. The fundamental principles of chemistry. An introduction to all text-books of chemistry. Authorized translation by Harry W. Morse. 361 pages. Cloth, $2.25. New York: Longmans, Green & Co.

Biltz, Heinrich and Wilhelm. Laboratory methods of inorganic chemistry. 273 pages, illustrated. Cloth, $3. New York: John Wiley & Sons.

Lewkowitsch, J. Chemical technology and analysis of oils, fats and waxes. Fourth edition. Three volumes, 562, 824 and 414 pages respectively. $15 net. New York: Macmillan Co.

Wang, Chung Yu. Antimony. Its history, chemistry, preparation, analysis, production and valuation. With complete bibliographies for students, manufacturers and users of antimony. With numerous illustrations. 227 pages. Cloth, $4 net. Philadelphia: Lippincott.

Sheldon, Walter Sheldon. The story of oil. 282 pages, illustrated. Cloth, $1 net. New York: Appleton.

Keane, C. Alexander. Modern organic chemistry. With 29 figures in the text. 517 pages. Cloth, $1.50 net. New York: Scribner.

Beck R. The nature of ore deposits. Translated and revised by Walter Harvey Weed. Illustrated. Cloth, $6. New York: Hill Publishing Co.

Mayer, Lucius W. Mining methods in Europe. Written after a visit to many of the metal and coal mines in Great Britain, France and Germany: illustrated with drawings and photographs for the most part by the author. 178 pages. Cloth, $2.50. New York: Hill Publishing Co.

Iddings, Jos. Paxson. Igneous rocks. Their chemical and mineral composition, with a discussion of the chemical and physical principles applicable to their study; and a statement of the qualitative and the quantitative systems of classifications in present use. 475 pages, illustrated. Cloth, $5. New York: John Wiley & Sons.

Stewart, R. Wallace. An elementary text-book of physics. With 48 illustrations, 141 pages. Cloth, $1.50 net. Philadelphia: Lippincott.

Cosgrove, J. Jos. Sewage purification and disposal. 230 pages, illustrated. Cloth, $3. Pittsburgh, Pa.: Standard Sanitary Manufacturing Co.

Moore, E. Crozier Sibbald. Sanitary engineering. A practical treatise on the collection, removal, and final disposal of sewage and house refuse, and the design and construction of works of drainage and sewerage, with numerous hydraulic tables, formulas and memoranda, including an extensive series of tables of velocity and discharge of pipes and sewers. Third edition, revised and in part rewritten by E. J. Silcock. In two volumes. Vol. 1: Sewerage, hydraulics, sewer and drain ventilation, sanitary fittings and apparatus. Vol. 2: Land drainage, sanitary notes, sewage disposal, refuse destructors, trade effluents, and sewage fungus. 566 and 428 pages respectively. Illustrated. Cloth, $14 net. Philadelphia: Lippincott.

BOOK REVIEWS.

Report on the Mining and Metallurgical Industries of Canada, 1907-8. Ottawa, Ont., Can.: Government Printing Office. 972 pages, with many illustrations, maps, etc.

Dr. Eugene Haanel's activity as the Director of Mines at Ottawa, Ontario, needs no comment in this journal. His commission reports on electric smelting of iron ore and steel making have made the Canadian Department of Mines famous all over the world, and some other reports, prepared under his direction, notably on zinc and peat, are also classics in their respective fields.

The present Report on the Mining and Metallurgical Industries of Canada is the latest product of this intensely practical activity of the Canadian Mines Department. "The report as a whole is comprehensive, and will meet the great demand made on the Mines Branch during the last year or two for special information on the subject. While the eminently practical character of the data furnished will enable the capitalist, manufacturer, and general reader to make deductions which should be invaluable when looking for profitable investment."

The report is very well written and profusely illustrated, with many maps, illustrations, etc. The report consists of two parts. The first (616 pages) relates to the general mining and metallurgical industries in Yukon Territory, British Columbia, Alberta, Ontario, Quebec, New Brunswick, Nova Scotia. The second part (300 pages) relates to structural materials (brick and tile, lime, sandstone, cement, etc.) in the various provinces. Mr. S. Groves is named as editor, and Messrs. D. D. Cairnes, R. R. Hedley, Fritz Cirkel, J. J. Bell, J. W. Bell and W. F. Jennison as special investigators in the different provinces.

* * *

Vectors and Vector Diagrams, Applied to the Alternating-Current Circuit. By William Cramp and Charles F. Smith. 252 pages, illustrated. Price, $2.50 net. London and New York: Longmans, Green & Co.

A valuable summary of the general principles of vector representation, vector algebra, multiplication of vectors, etc., with special reference to applications in alternating-current theory, examples being taken from the theory of transformers, of single-phase and polyphase motors, etc. It is a useful and practical book for engineers interested in the theory of alternating-current phenomena.

Electrochemical and Metallurgical Industry

VOL. VII. NEW YORK, AUGUST, 1909 No. 8

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH.D.....*President*
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Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, AUGUST, 1909.

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BOOK REVIEWS.....

The Proposed New Home of the Chemists' Club

The note, printed elsewhere in this issue on the new proposed Chemical Building to be erected by the Chemists' Club of New York, will be of interest to every chemist in the United States. The Chemists' Club has always lived up to the program of its founders to make it the professional home of all chemists of this country. In its cosy club house the various chemical societies have met and felt at home. "There the young graduate comes in contact with the teacher of our science who has made an international reputation for himself, and there the young beginner with the proud distinction of earning $15 per week meets on an equal social footing the millionaire captain of industry." It is not too much to say that the New York Chemists' Club has created a true democracy of American chemists. It is natural that it desires a bigger home. And if this is successfully attained, the more difficult task will also be solved to transplant the old spirit into the new home.

The Labor Problem.

Dr. Dudley's admirable presidential address to the American Society for Testing Materials on the subject of engineering responsibility contains a brief side remark on the labor problem. This remark is so pertinent that we quote it here without further comment, besides saying that, after labor unions have evidently come to stay as an essential part of the modern industrial system, they are necessarily subject to the same evolution as the system of which they form a part. Dr. Dudley says: "We are firmly convinced that if labor organizations would devote less time and energy to contention with employers and more effort toward making the organization stand for skill and plain, simple honesty in workmanship, and for fair dealing with, and reasonable devotion to, the interests of employers, all questions connected with the recognition of the union would fade into insignificance, and collective bargaining would be welcomed, nay, even sought for, by those who are managing the great industries of our modern civilization."

Electrode Losses.

Mr. C. A. Hansen's article in this issue brings up a very interesting and most important problem in electric furnace design. Since the electrodes are the means for transporting electrical energy into the furnace, they must be good electrical conductors, and since there is in general a close parallelism between thermal and electric conductivity, it is clear that with respect to the heat insulation of the furnace the electrodes are liable to form the weakest point with improper design. That much can be done, however, by properly dimensioning the electrodes is evident from the results described in Mr. Hansen's article. One of Mr. Hansen's results is that within reasonable limits the efficiency of a graphite electrode increases rapidly with increasing current density (or, what is the same, with decreasing cross section). The research laboratory of

The General Electric Company must be congratulated on having taken up a systematic investigation of this important problem, and further reports by Mr Hansen on the results of this [illegible] will be awaited with great interest.

Gas Producers for Low-Grade Fuel.

In various instances in recent years we have witnessed remarkable changes in the attractiveness of low-grade ore propositions. Deposits which would not have been touched so very long ago are now being worked successfully. This is generally the result of high-grade ores getting scarce, together with advances in metallurgical art. As a matter of fact, both these elements are intimately connected, as necessity is the mother of invention. It seems that we are about to witness quite an analagous development with fuel. Forced by necessity, Europe has already largely made use of lignite and peat. With the enormous deposits of these low-grade fuels in this country, we certainly must expect that they will be used when we know how. But it is likely that the development will not by any means be exactly parallel to the development in Europe, in view of the differences of conditions. In Europe dry distillation of peat and lignite, with recovery of by-products, has proved attractive, though their use in gas producers has also been tried. In a discussion of this subject, in our October issue, 1907, we said that we do not expect great developments in this country along the lines of by-product coke ovens for peat and lignite, and that our hopes rest rather in the gas producer for low-grade fuels. We are glad to see that the same position is taken in the interesting paper of Dr. Zwingenberger, presented at the Brooklyn meeting of the American Institute of Chemical Engineers, and published in this issue. His reasons why he advises not to attempt the recovery of by-products in plants of moderate size, say of 1000 or 1500 hp. are certainly commercially sound.

* * *

Dr. Zwingenberger's paper is, however, especially interesting in the discussion of the fundamental problem—the proper design of the gas producer for these low-grade fuels. Much very valuable work has already been done by the U. S. Geological Survey in its extended gas producer tests. Dr Zwingenberger's producer is a combination of gas producer and coking chamber, and the design is original in various respects. A principal difference between his coking oven or gas producer and other designs is that in the latter the gas leaves the producer at the top or center of the producer, while it leaves the Zwingenberger producer at the bottom. This is due to the desire to change the fuel wholly into gas and to avoid the formation of tar—which is a source of great trouble in the use of peat or lignite. In the Zwingenberger construction the tar formed passes through the zone of medium temperature, where a great deal is transformed into permanent gas, while the little rest cannot escape decomposition, because before leaving the producer it has to pass through a very hot zone, the temperature of which is close to the hottest zone of the combustion chamber. It will be interesting to watch how this design will behave in commercial continuous operation. At any rate, Dr. Zwingenberger's paper brings out clearly some of the principal points that must be considered in gas-producer design for lignite and peat.

The Active Forces in the Iron and Steel Industry.

"Oh, wad some power the giftie gie us, to see oursells as ithers see us." So, too, would that we could burst the trammels of the now and from a remote spot, shorn from the limits of time, view the course of the iron and steel industry through the years with the present marked only as by a milestone. The resolution of forces acting at a given instant is simple, but the course over a period of time is a curve made up of an infinite number of tangents, each a resolution of the forces acting at the moment. The forces change in direction and in intensity. They even disappear, while new ones appear. What a multitude of forces there have been. Many centuries ago the desire to kill produced the Damascus blade, then the need of defense produced armor. The harnessing of steam, of electricity, and of the inflammable gases have come in their turn. Each of these instruments brought into use has exerted a double influence, facilitating production and stimulating consumption. The history of the development of these three utilities is the history of the development of the iron and steel industry, with but few chapters omitted. Among the most distinct of the many forces acting at the present moment are the demand for fine steel for automobiles and flying machines, children of the gas engine, and the facilitating of the production of fine steel through the use of electricity. For illustrating our thought reference to mathematics can be made, but for seeking the desired view the science is useless because we cannot furnish it the infinitude of data without which it could not proceed. We are driven to a mere tracing of the variations which have occurred in the most prominent forces acting through the past to the present. None has disappeared. The desire to kill, which produced Damascus blades in pounds, now produces Dreadnoughts in thousands of tons. The merest approach to a real analysis is impossible, when a book could contain little. Here there can be but a few random words, and they will not have failed of their purpose if they succeed in directing a moment's thought to some few of the forces acting to produce the course of the iron and steel industry.

* * *

Until 1905 the curve of the world's production of pig iron was unmistakably convex to the axis of abscissae. From 1905 through 1907 it was concave, but still trended upward; in 1908 it dipped downward. It had done so before in individual years. The smoothing curve of the future may obliterate these movements as trifling irregularities. In the United States the curve of pig iron production has diverged but slightly from that written by a mathematical law; the movement has been practically that of doubling the tonnage every 10 years. The divergences have been chiefly in individual years. The decennial periods closing with 1907 have shown the following tonnages:

1828-37	2,000,000
1838-47	4,300,000
1848-57	6,500,000
1858-67	8,760,578
1868-77	19,984,735
1878-87	42,484,217
1888-97	82,236,958
1898-1907	181,470,757

Through 1867 the curve was convex to the axis of abscissae.

but the curvature fell short of that in the mathematical curve mentioned; since 1867 the curvature has exceeded it. No such curve can be continued indefinitely. Civilization is thousands of years old, and we are dealing with tens of years. Noting that production in 1908 was less than two-thirds that of 1907 and 12 per cent less than the average in the 10 years ending 1907, while 1909 production is falling much short of 1907, one might, at a glance, suggest that the limits of the decennial periods have been injudiciously chosen, but a scrutiny of annual figures shows that no division would fail to produce a curve closely adhering to that written by a doubling every 10 years. Thus it remains that the curve has heretofore been convex to the horizontal axis. The knowledge that the dip in 1908 was caused by a financial panic the effect of which has largely worn off, and other considerations, including the increase this year, assure us that no permanent downward dip has been established, but whether the direction of curvature has been, or is being, changed at this time cannot be determined by this means. We can hardly draw a tangent at the present; it is utterly impossible from the data already cited to project the curve.

* * *

A simple proof that we cannot is furnished by a reference to statistics of steel production. At a given moment steel production and pig-iron production are in relation, but at different periods the relation varies. We made pig iron before steel. Prior to 1875 the tonnage of steel ingots was less than 10 per cent of the tonnage of pig iron; in 1906 and 1907 the tonnage of steel ingots and castings exceeded 90 per cent of the pig-iron production. The causes of the changing relation are well understood. The steel has been supplanting iron used in other forms, the ingot statistics are robbed of part of their value by including the remelting of new steel scrap produced in the rolling mill, and there is old material remelted. The production of steel has doubled every six or seven years. The production of rolled iron and steel, covering merchantable forms, increases rather slowly at first, but the last two doublings occurred in less than 20 years. The data cited are merely the quantitative statement of the result of influences which it would be burdensome to investigate. We should not yield to the fear that analysis of these quantities is useless for guidance, but should, on the contrary, see the necessity of going back to first principles. We make pig iron merely to accomplish the first metallurgical stage of converting the useless iron ore of the earth into useful material. The pig iron production is the addition to our store of useful material. It is at the blast furnace that we should measure the flow of the stream; there are no subsequent additions except the minor one to be noted. Material is lost by oxidation and by passing through uses which leave it in too small pieces to warrant reclamation. Portions of the store in use are reworked at longer or shorter intervals, a detail which is becoming increasingly important to the general alignment of the industry. As representing the flow of formerly useless material into actual use, the blast-furnace or pig iron statistics are incorrect in two particulars; some ore passes through the open-hearth furnace and not through the blast furnace and some scale or other reoxidizing iron passes through the blast furnace. These particulars are relatively unimportant, and it chances that the signs of the corrections due to them are opposite.

* * *

The atmosphere seems clearer when we look at our store of iron, rather that at our annual production, to determine our tangents or produce our curves. What is the present store? To the middle of this year we have made 375,000,000 tons of pig iron in the United States. This iron was produced by each decade, making approximately double as much as the preceding decade; if this had been done strictly, the production of a decade would have exactly equalled the total previous production. Our present store of iron and steel, expressed in terms of pig iron required to make it, is perhaps two-thirds the total production, or somewhere in the neighborhood of 250,000,000 tons. It has required a third of a century for our population to double, so that the increase in population has borne no important relation to the increase in requirements. When our population was half as large as at present we had made only one-eighth as much pig iron. There has been produced for domestic use about 50,000,000 tons of steel rails, and there are in use about 40,000,000 tons. We have built steam railroads until we have a mile for every 13 sq. miles of area, and are not building as rapidly as formerly. In a few years we have had a rush of replacing wooden cars with steel construction, and may be able to proceed more moderately in future. We have erected steel office buildings to house several millions of our population.

* * *

Without going farther, what do these achievements promise? The curve of production in these directions is not likely to be so convex to the horizontal axis as has been the curve of total production or the curve of our total store. The curve may even change its direction of curvature, although still trending upward. Let us forsake tonnage considerations for a moment and observe if there is anything else to be seen. The time was when iron rails were used, averaging, say, 45 lb. to 65 lb. per yard. Such rails would nowadays last the time required for the passage of the first pair of drivers of a modern locomotive upon them. Then came the light steel rail, then heavier sections. The traffic per mile of road has greatly increased, especially on trunk lines; the life measured in volume of traffic may have decreased; measured in time it has greatly decreased. The annual sinking fund for replacement has risen and is larger proportionate to interest charge, dictating, with mathematical precision, the employment of finer steel to decrease greatly the sinking fund charge while increasing but slightly the interest charge. A practical illustration is the installation at Gary to make 300 tons of electric steel rails a day. The height of office buildings and the length of bridge spans has been pushed until the loads compel higher tensile strengths at higher costs per ton of material. The demand for fine steel for automobile construction is growing wonderfully; the general manager of the American Motor Car Manufacturers' Association estimates that plans for next year call for building 200,000 cars against 70,000 cars this year; the tangent to that curve of demand is almost vertical at the moment. We may be in doubt whether the curve of tonnage will remain convex to the horizontal, we cannot doubt that the curve of quality is strongly convex.

The Proposed New Home of the Chemists' Club in New York.

A site has been secured for the proposed new Chemical Building in New York City. After long and careful search by a committee, headed by Dr. Charles F. McKenna, a plot 50 ft. x 100 ft. at 50 to 56 East Forty-first Street, has been selected and the negotiations for its purchase have now been brought to a satisfactory close. The land will be held at the disposal of the friends of the Chemists' Club until it shall have been definitely ascertained whether the plans can be carried out within a reasonable time.

The property is within a two-minutes' walk of the Grand Central Station, the Subway Express Station, and the proposed terminals of the tunnels to Long Island and New Jersey; while the proximity to the New York Public Library, in Fifth Avenue, opposite Forty-first Street, and the Engineering Societies' Building, in Thirty-ninth Street, accentuates the wisdom of the choice. At the same time, Forty-first Street is interrupted by the New York Public Library and the Park Avenue cut and can never become a thoroughfare for heavy traffic.

A real estate company is to be formed to erect an 8 to 10 story building, the lower portion of which will be especially adapted to the needs of the Chemists' Club and its allied societies.

The upper floors will be constructed with a view to accommodating the laboratories and offices of analytical, research and commercial chemists, physicists, sanitary and pathological experts. Some of the special attractions, besides well-lighted and ventilated space in a properly constructed scientific building, would be joint telephone service, the availability of a large scientific library, a co-operative storeroom for standard apparatus and chemicals; possibly the provision of special apparatus for that class of operations which are only occasionally performed in any one laboratory.

If a sufficient demand be demonstrated, bedrooms can be provided for individual chemists or the club may decide to provide sleeping accommodations for its members.

The success of the plan will depend upon the readiness with which friends of the club will purchase the stock of the company. At present a canvass is being made among the members of the club to get exact information on certain concrete questions which will decide the probable income, the cost of construction, etc.

Dr. Morris Loeb is the president of the club.

The Iron and Steel Market.

The decrease in buying of steel products in July was less than expected. While there has been no large business done the flow of small orders has kept up very well. Additional specifications have been received on old contracts, reinforcing the large mass received in the second quarter, so that altogether the steel mills have an ample supply of business on which to operate in the usually dull summer months.

The trend of steel prices has been slightly upward, but the movement is not necessarily important as regards the future, as much will depend on the relation between demand and capacity. When mills have advanced prices it has been chiefly through the encouragement derived from there being a large tonnage under contract, specifications against which are stimulated by advances in the open market.

The iron and steel market has been particularly the creature of sentiment this year. A large part of the trade may be said to have been plunged in the depths of despair when the price maintenance policy was abandoned Feb. 18, to make way for such competition and price reductions as would bring a larger volume of business, while during the second quarter optimism grew rapidly so that by the end of June the position and prospects were regarded with almost unbounded enthusiasm.

The changes in actual conditions have been of much less range than the changes in sentiment. The actual rate of output of finished steel products probably has not shown a variation of as much as 10 per cent above or below the mean during the first seven months of the year. The rate of pig-iron production has shown considerably less variation than this, but that rate has not been strictly indicative of the steel-making rate, for the reason that when the steel trade was quietest the merchant furnaces were accumulating pig iron, while of late when the steel mills have been more active the merchant stocks have probably been drawn upon.

It is of interest, however, to note that the total pig-iron production in the first half of the year was about 11,000,000 tons, while the lowest rate shown for any month in the half year would have resulted in an output of fully 10,500,000 tons and the highest rate shown for any month would have resulted in an output of somewhat less than 12,000,000 tons, so that the extreme rates varied from their mean by only about 6 per cent. The June rate, the maximum of the half year, was a trifle under 24,000,000 tons a year, while the July rate has probably slightly exceeded 24,000,000 tons a year. The maximum rate recorded was 28,000,000 tons, in October, 1907, while the best calendar year's production, that of 1907, was 25,781,361 tons

The month of July has seen an unusual number of labor disturbances, there being strikes against the Pressed Steel Car Company and Standard Steel Car Company, somewhat decreasing plate shipments of the mills; a threatened strike of coal miners against the Pittsburgh Coal Company, a minor strike of switchmen at McKeesport against the National Tube Company, and the serious conflict between the American Sheet & Tin Plate Company and its men. This company declared that after June 30 it would operate all its mills on the open-shop principle, its scale agreement with the Amalgamated Association, controlling the hot-mill labor in a little over half its sheet and tin mills, expiring June 30, and its agreement with the Tin Plate Workers' International Protective Association of America, covering about two-thirds of its tinning capacity, expiring July 15. After the first promulgation the open-shop order was modified so as not to become effective with tin-house labor until after July 15.

The night of June 30 all the Amalgamated Association men walked out with the exception of those in the Guernsey sheet mill, at Cambridge, Ohio. The night of July 15 all the tin-house organization's men walked out except a few at the two New Kensington plants. Thereupon the company commenced its efforts to operate the closed plants with non-union labor, while the unions started their efforts to close the non-union plants which had been operating. The honors have been about equally divided, which is a surprise since the more general expectation, and certainly that of the company itself, was that no very serious resistance would be offered.

Pig Iron.

Pig iron has been strong in all markets, but without noteworthy advances except in the case of Southern iron. At the close of June the $11.50, Birmingham, price for third quarter had been withdrawn by many interests; early in July it disappeared entirely, and after a few sales at $12, the market advanced squarely to $12.50, Birmingham, for third quarter and $13 for fourth quarter, an advance of $1.50 from the beginning of June to the middle of July.

The International Harvester Company and American Radiator Company have been the largest purchasers of Northern and Southern foundry iron, each taking in the neighborhood of 50,000 tons. Steel-making pig iron, particularly Bessemer, has been fairly active. There has been a moderate movement of basic in the Pittsburgh market, at $15, valley. Early in the month the Jones & Laughlin Steel Company bought 25,000 tons of standard Bessemer from the Bessemer Pig Iron Association at $15.25, valley, or $16.15 Pittsburgh, for third quarter delivery. July 13 the Youngstown Sheet & Tube Com-

pany bought an equal tonnage from the same interests at $15.50, valley, for delivery through October. Negotiations were then set on foot by the chairman of the furnace association to gather together all the Bessemer iron available for early delivery and offer a block to the United States Steel Corporation.

The valley market (Pittsburgh delivery 90 cents higher) is quotable as follows: No. 2 foundry, malleable and basic, $15 to $15.25 according to delivery; forge, $14; Bessemer, $15.50 to $16.

Billets and Sheet Bars.

Deliveries of billets and sheet bars were slightly reduced in July owing to some mills being closed for repairs and on account of labor difficulties. Bessemer continues quotable at $23 for billets and $25 for sheet bars, soft open-hearth steel commanding a premium of about $1 a ton. Forging billets have been advanced by most sellers to $27, the usual spread above rolling billets being $2.

Finished Materials.

The advances of $1 a ton noted in last report as made on bars, plates and shapes by a number of producers have been followed by similar advances by all other producers, and the market is squarely on the basis of $1.25 for bars and $1.35 for plates and shapes, quotations $1 a ton higher being frequently made. The concessions on sheets, which generally decreased during June, have been almost entirely withdrawn. Iron bars have become firmer, the former nominal price of $1.45, Pittsburgh, being fairly well established. Wrought iron pipe has advanced a point, or about $2 a ton, steel pipe being unchanged.

The market is quotable as follows, f.o.b., Pittsburgh:

Steel bars, $1.25, base.

Iron bars, $1.45, base.

Plates, $1.35 to $1.40.

Shapes, $1.35 to $1.40.

Standard rails, $28 for Bessemer and $30 for open-hearth, f.o.b. mill; light rails, 25 lb. to 45-lb., $26.50 to $27.50.

Sheets, 28-gage, black, $2.20; galvanized, $3.25.

Tin plates, $3.40 for 100 lb. cokes.

Merchant steel pipe, 3/4-in. to 6 in., inclusive, nominally 80 per cent off in "jobbers' carloads"; actual inside price, 81 and 5 off.

Plain wire, $1.50, base; wire nails, $1.70, base; painted barb wire, $1.70; galvanized barb wire, $2.

Detroit Meeting of American Chemical Society.

The meeting of the American Chemical Society, held at Detroit, from June 29 to July 2, was more largely attended than any summer meeting in its history and all the members returned to their homes enthusiastic over the work accomplished by the various Divisions of the society.

Meetings were held by the Division of Industrial Chemists and Chemical Engineers, the Division of Physical and Inorganic Chemistry, the Division of Organic Chemistry, the Division of Fertilizer Chemistry, and the Division of Agricultural and Food Chemistry, and by the Sections of Biological Chemistry and Pharmaceutical Chemistry and the Section of Chemical Education. In all 186 papers were presented.

Besides the reading of the various papers the point of special interest were the largely attended meetings of the Division of Industrial Chemists and Chemical Engineers, where representatives were present from all parts of the country. Perhaps the "experience meeting" before this division on Friday morning was the most entertaining feature of their program, for many ideas of value were brought out and the discussion was general. It seemed as if almost every member had some interesting fact which bore upon the experience of others and the hour for adjournment was delayed to the very latest possible moment on account of the keen interest aroused. It is quite noteworthy that the mantle of secrecy which has enveloped so many of the chemical industries and industrial chemists in the past appears to be falling away under this enthusiasm and both the industries and the industrial chemists themselves find that they gain more than they lose thereby. In this connection it might be added that a considerable number of chemical corporations are joining the society as such and are heartily entering into the spirit of progress with which the society is so thoroughly imbued.

The Section of Pharmaceutical Chemistry, which held its first meeting in Baltimore, was surprisingly well attended at Detroit with representative pharmaceutical chemists from various sections of the country. The chief matter of importance before the section was the question of the advisability of forming a Division of Pharmaceutical Chemistry. After the matter was discussed by almost everyone present and many letters were read from pharmaceutical chemists, it was unanimously voted to request the council to establish such a division and a strong organization was formed with Prof. A. B. Stevens, of Ann Arbor, as chairman; B. L. Murray, secretary; J. P. Remington, Edw. Kremers and J. M. Francis, executive committee.

The social features of the meeting were many. A complimentary smoker was given by the Society of Detroit Chemists to the visiting chemists on Tuesday evening, and a banquet on Thursday night. On Wednesday afternoon the chemists were the guests of Parke, Davis & Company, and visited the works of this well-known firm, were entertained there at dinner and were given an evening boat ride on the Detroit River and Lake St. Claire before returning. Thursday was spent in Ann Arbor as the guests of the regents of the University of Michigan and three papers of general interest were there presented in general session. The rest of the day was turned over to the Section of Chemical Education, where papers dealing with methods of instruction were read. During the day the members visited the new laboratories of the University of Michigan, and were entertained at luncheon through the courtesy of the regents.

Many manufacturing works and chemical establishments were opened to the visitors in Detroit, among which may perhaps be especially mentioned Acme White Lead & Color Works, Detroit Salt Company, Hiram Walker & Sons, Hoskins Manufacturing Company and the various automobile factories which have so greatly added to the industrial life of Detroit.

A steadily increasing number of members of the society are making it a point to attend the meetings, and it is interesting to note that more and more chemical corporations are appreciating the value of these meetings to their chemists and are insisting upon their attendance, in most cases bearing all the expenses of the trip.

Electric Smelting of Iron Ore in Sweden.

With reference to the plans of the Trollhattans Elektriska Jarnverk, noticed in the letter of Mr. H. Hultegard, on page 300 of our last issue, another correspondent in Sweden sends us some further information.

The company has been incorporated with a minimum capital of 600,000 kr ($160,000), the inventors having allied themselves with some prominent steel men as promoters of the organization. In this way the common interest of the Swedish manufacturers in the development of a successful process for the electric smelting of iron ore has caused them to combine for the purpose of obtaining experience in working the process on a commercial scale before entering upon what may be called "large-scale operations."

The new works will be situated near Gothenburg at Trollhattan where large water-power developments have been carried out by the Swedish Government. The company has an option on 10,000 hp at a price of 37.50 kr ($10) per kw-year for the first 10 years, and at 50 kr ($13.30) for the following 10 years. Present plans cover the erection of three furnaces, two of which will be working while the remaining one will be held in reserve. Each furnace will have a capacity of 2500 hp, and will produce 7500 tons of pig iron a year. The intention is

to use coke as a reducing agent, because coke in this furnace gives a pig iron having qualities equal to that of the charcoal iron, and coke is cheaper than charcoal, which otherwise is used almost exclusively in Swedish blast furnaces. A suitable metallurgical coke can be obtained for 21 kr. ($5.63) per ton. The ore used will be shipped from the mines at Grangesberg, situated about 200 miles from the furnace, part of which distance is covered by water transportation.

The cost of producing one ton of pig iron in kr. (1 kr. = 1 Swedish crown = 26.8 cents) is figured as follows for a production of 15,000 metric tons of pig iron at Trollhattan:

		Kr. per ton pig.
1,750 kg. ore (60 deg. Fe).....	7.00 kr. per ton ore	
Freight to Trollhattan.....	4.50 kr. per ton ore	
Unloading at Trollhattan.....	0.30 kr. per ton ore	
	11.80 kr. per ton ore	20.00
300 kg. coke (21 kr. per ton)...		6.30
100 kg. limestone (6 kr. per ton)...		.60
One-third hp-year electric power (27.60 kr. per hp-year)...		9.20
Salaries and wages, including crushing and transports....		3.50
Cost of electrodes, 8 kg., at 0.25 kr.....		2.00
Maintenance and general expenses.....		4.50
Interest and sinking fund (11 per cent on 1/3×365,000)...		1.71
Analyzing costs.....		.20
Office and organization.....		1.00
Royalty		1.00
Total per ton of pig.....		51.00

It is, therefore, calculated that the pig iron can be produced at cost of 51 kr. per metric ton, which is equivalent to $13.67 per metric ton, or $12.40 per short ton. It is assumed that the selling price will be at least 58 kr. per metric ton, or $14.10 per short ton. Therefore, with a production of 15,000 tons a year and a capital investment of 600,000 kr. the profits would amount to at least 15 per cent. The cost sheet for the plant is given as follows:

	Kronen.	Dollars.
Three electric furnaces of 2500 hp. including transformers, etc.....	150,000	40,000
Installation.....	15,000	4,000
Crushing machinery for 35,000 tons of ore and 7000 tons of coke per year.....	9,000	2,400
Motors, small transformers, lighting, etc.....	6,000	1,600
Apparatus for transportation of ore from docks to furnaces, etc.....	15,000	4,000
Apparatus for transportation of iron, slag, etc., in plant	12,000	3,200
Furnace building and storehouses.....	60,000	16,000
Building for crusher plant.....	4,000	1,060
Grading, fencing, work on docks.....	15,000	4,000
Office and laboratory.....	20,000	5,300
Superintendence and unforeseen expenditures.....	34,000	9,060
Total	340,000	90,620
Licenses	25,000	6,660
Working capital.....	235,000	62,720
Total	600,000	160,000

Some of the items given above, which are almost identical with those given by Mr. Hulleyärd in our last issue, seem to be somewhat optimistic, but it is to be hoped that the comfortable margin of profits calculated will make it profitable for the plant to carry somewhat heavier first cost than has been assumed.

The outcome of this enterprise will be watched with great interest by those acquainted with the development of the electric smelting of iron ore in places where conditions are favorable to such a process. So far the experimental furnace has been running only for a period to be measured by days or weeks, and it remains to be seen whether the design will stand the crucial test of running commercially over long periods. The successful outcome of the enterprise will in many cases have an important bearing upon the iron industry.

Engineering Responsibility.

Dr. CHARLES B. DUDLEY'S recent presidential address before the American Society for Testing Materials discussed the causes of failures in engineering. Failures may be ascribed to one or more of the four following causes, viz., to bad material, bad workmanship, bad or faulty design, or to unfair treatment.

Material is bad when it is different from what those who put it in service had a reasonable right to expect it to be. Explanations or excuses for poor materials are the consideration of price; further, the fact that processes of manufacture do not always and every time yield the desired first quality product; finally, the "most pernicious" attempt, so common everywhere on the part of producers, to usurp the legitimate functions of both the consumer and his expert.

With respect to bad workmanship, Dr. Dudley thinks that the piecework system has been somewhat antagonistic to quality of work, though he is unable to suggest a remedy. Dr. Dudley thinks from the indications which he has been able to gather that the increase of efficiency of workmen, following voluntary increases in wages, has been most disappointing. A very pertinent side remark of Dr. Dudley on labor unions is quoted on our first editorial page.

As to faulty design, it is pointed out that the designing engineer cannot always accurately compute the strains to which the whole or parts of the structure will be subjected. "The engineer who makes the design, perhaps more often than any of us, is at the end of his knowledge, and if failure comes, due to defective or faulty design, deserves, in our opinion, more sympathy than any one else involved." Further, the designing engineer is often overruled by those who control expenses.

Finally, as to unfair treatment. A bridge, designed for not over two-thirds the live load which is actually put on it, is unfairly treated. Also, materials entering into a structure may be unfairly treated; if the calculated strains are too high, or, what amounts to the same thing, too low a factor of safety is employed, materials are unfairly used.

Dr. Dudley concluded as follows: "Would not an infusion of genuine conscientiousness into our industrial life bring an amelioration? If a little less energy was expended in the mad race for wealth and a little more zeal manifested in maintaining the rugged virtues of honesty, integrity and fair dealing, would not some of the friction and contention of our present commercial life disappear? We must all live together, and surely harmony is better than contention. There are some things in life of more value than money."

CORRESPONDENCE

Electric Resistivity of Fused Steel.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—In the table which you published on page 300 of your issue of July, 1909, and forming a part of a communication from me, there are unfortunately four typographical errors and I would be obliged if you would publish this correction of them in your next issue; you will notice that the errors were not in the original copy sent you.

In the second column, third line, the temperature should be 1280 and not 280.

In the third column, second line, the number should be 0.000,200 and not 0.000,000.

In the third column, fourth line, the number should be 0.000,114 and not 0.000,114.

In the fifth column, third line, the figures should be 6,250 and not 6,502.

PHILADELPHIA, PA. CARL HERING.

[We greatly regret these typographical errors. In view of the importance of the matter, we herewith reproduce again the table, corrected:

		Resistivity		Conductivity	
Material.	Temp. C. deg.	cm.	inch.	cm.	inch.
1 Fused steel....	not given	0.000,140	0.000,055	7,140	18,100
2 Fused steel....	not given	0.000,200	0.000,079	5,000	12,700
3 Fused cast iron	1280-1430	0.000,16	0.000,063	6,250	15,900
4 Iron and cast steel .....about	1300	0.000,114	0.000,045	8,750	22,200
5 Puddle steel...	15 deg.	0.000,014,1	0.000,005,54	71,100	181,000
6 Bessemer steel.	15 deg.	0.000,023,2	0.000,009,16	43,000	109,000
7 Pure copper....	15 deg.	0.000,001,687	0.000,000,664	592,800	1,505,000

The reference numbers 1 to 7 designate the origin of the data, for which see page 300 of our last issue. In the table the resistivity units are in terms of the ohm, cb. cm. or the ohm, cb. in. units, and the conductivities in the reciprocal ohm (or mho), cb. cm. or cb. in. units.—EDITOR.]

The Centering of Great Industries in the New York Metropolitan District.*

BY DR. CHARLES F. MCKENNA.

If on a map of Greater New York and its environs we were to draw a line from the city of Yonkers, on the Hudson, in New York, to the city of Paterson, on the Passaic, in New Jersey and then extend it southerly to the city of Newark, to Elizabeth to Perth Amboy, around Staten Island, thence to and around the easterly boundaries of the Boroughs of Queens and the Bronx to the city of Yonkers again, we should have circumscribed a territory approximately 700 sq. miles in area, whose great natural advantages and acquired advantages for the economical manufacture of the greatest variety of materials have brought about most happy and satisfactory results for commerce and technology.

In this territory will be found located the great sugar refineries of Yonkers, Edgewater, Jersey City, Brooklyn, and Greenpoint; the silk and woolen mills of Paterson, Passaic, and Hoboken; the metal smelting works of Newark, Irvington Perth Amboy, Carteret, Staten Island, Bayonne, and Laurel Hill; the corn works of Shadyside, Newark, Perth Amboy, Bayonne, Staten Island, New York City, Bushwick, and Greenpoint; the jute mills and fiber works of Brooklyn; the linen and cotton thread works of Paterson and Newark; the lead and white lead works and linseed oil plants of Staten Island and Brooklyn; the paint and varnish works of Newark, Jersey City Long Island City, and Brooklyn; the lard refineries of Guttenberg, Jersey City, and New York City; the cotton-oil refineries of Guttenburg; the great soap works of Babbitt, N. J., and New York and Jersey City and Staten Island; the glue and fertilizer industry of Newark and Barren Island; and, lastly, the great mineral-oil refineries of Brooklyn, Edgewater, Bayonne, Bayway, and Greenpoint.

It has not been my principal view to refer to the other very large manufacturing interests for which the district is famous such as the production of clothing and of the great variety of general articles of wood, leather, metal or whatsoever material, or to the manufacture solely intended for supplying utilities to the district, such as gas-making; I mean rather to consider the great fundamental industries in which raw material is treated in a large way for the supply of the world's markets with staples. Those listed thus make a very impressive array. Some general figures about them make an astonishing showing.

Eighty per cent of the 6,000,000,000 lb. of refined sugar used in the United States is refined here; one concern which refines 80 per cent of the petroleum in the United States has here five of the largest of its 20 refineries, and another concern one refinery; the silk mills of the district, including throwing, weaving and dyeing works, are more than 60 per cent of all in the country and produce more than $60,000,000 worth of goods, and so on through most of the industries which seem almost peculiar to the district, so concentrated is the country's production therein.

The foreign commerce figures of this and certain other large ports are striking

TOTAL IMPORTS, FISCAL YEAR, [illegible]

New York City	$853,[illegible]
Boston	[illegible]
Philadelphia	[illegible]
Baltimore	[illegible]
San Francisco	[illegible]
New Orleans	[illegible]
All other points	[illegible]
	[illegible]

TOTAL EXPORTS, FISCAL YEAR [illegible]

New York City	[illegible]
Galveston	[illegible]
New Orleans	[illegible]
Boston	[illegible]
Philadelphia	[illegible]
All other ports	[illegible]
	[illegible]

But the census figures for all manufacturing industries hereabouts also contain some statistical truths of importance

*Extracts from a paper presented at the Brooklyn meeting of the American Institute of Chemical Engineers. The full paper will be published in the Transactions of the Institute.

INDUSTRIES OF METROPOLITAN DISTRICT.

COMPARATIVE RETURNS FOR 1900 AND 1905 FROM MUNICIPALITIES WITH POPULATIONS EXCEEDING 8000.

	Number		Aggregate Value of Products.	
	1900.	1905.	1900.	1905.
New York City	9,243	10,839	$1,172,870,261	$1,526,523,006
Yonkers	[illegible]	[illegible]	17,303,590	33,548,088
	19,350	20,944	$1,190,173,951	$1,560,071,094
State of New York	35,057	37,193	$1,891,830,872	$2,488,345,579
Bayonne	63	58	$38,601,420	$60,633,701
Bloomfield	39	33	3,370,924	4,645,483
Elizabeth	141	124	22,861,375	29,300,801
Hackensack	21	23	782,232	1,488,358
Harrison	41	41	6,086,477	8,408,924
Hoboken	94	279	10,483,079	14,077,305
Jersey City	136	628	72,920,690	78,749,934
Kearney	16	18	1,697,082	4,427,904
Montclair	23	19	693,592	921,145
Newark	1573	1600	112,728,045	130,955,227
Orange	74	66	2,995,688	6,150,635
East Orange	22	17	2,086,910	2,326,552
Passaic	77	95	12,804,805	22,782,725
Paterson	487	583	48,502,044	54,673,083
Perth Amboy	47	53	14,061,052	34,860,402
Union	57	77	3,403,136	3,512,451
West Hoboken	65	95	4,760,436	5,947,267
Metropolitan District in New Jersey	3,409	3,732	$358,736,936	$479,592,957
State of New Jersey	6,415	7,010	553,005,684	774,369,025

Summary.

Metropolitan District, New York	19,350	20,944	$1,190,173,951	$1,560,071,094
Metropolitan District New Jersey	3,501	3,781	301,174,370	483,165,091
Met. District, Total	22,851	24,725	$1,551,348,321	$2,043,236,185
Rest of U. S.	184,711	191,537	$9,859,772,801	$12,758,910,902
Total of United States	207,562	216,262	$11,411,121,122	$14,802,147,087

From the above table it will be seen that the States of New York and New Jersey, which contain about one-eighth of the population of the United States, produce within their bounds nearly a quarter of the aggregate national manufactures. Of the three and a quarter billions made in these two States about two billions fall to the share of the Metropolitan District, or about one seventh of the entire production of the United States, while its population may be estimated at about one-twelfth of the total. The importance of the district as a factor in our national industrial economy is thus amply illustrated With its two-billion annual product of varied manufactures, the Metropolitan District far outstrips the other general manufacturing cities in the country Chicago being next in importance with one billion dollars; Philadelphia and Camden following with $625,000,000, and Boston with the neighboring cities showing about $360,000,000.

The manufacturing capital in the whole of the United States was, in 1905, about $13,000,000,000, or 86 per cent of the annual product The proportion shown for the Metropolitan District was about 72 per cent of the annual product. Thus the Metropolitan District gets a larger return on capital invested than the rest of the country.

Cost of Labor.—By the census figures the amount of wages paid in the entire country on the product of $14,802,000,000 in 1905 was $2,610,000,000, or about 18 per cent. A separate figure for the Metropolitan District was about 16 per cent. This again can be laid to high value of machine output

The author concludes by expressing the belief that the territory thus described and recognized as the great Metropolitan District is destined to become the most interesting technological center in the world and the seat of the most varied and the largest establishments treating raw materials for the production of staples

Natural Causes for Growth.—It is well for the citizens of the metropolis to understand why these industries have been attracted to it, how they can be held and encouraged to increase, and how others may be induced to settle within the same area.

The location of great industries sometimes move the world almost as much as political and great popular movements. The cotton of Manchester, the iron of Cleveland, the soda of Newcastle in resisting competition of place and of process, by being

have affected the destinies of England beyond ... fight of Pittsburgh against the Lake district, the South and the seaboard will result, though a strife among brothers, in the absolute domination of the United States in the iron and steel trade of the world, while the contest between the cotton mills of New England against the advancing front of the Southern mills has brought about in the former much attention to detail and in economy, and such application of higher technical skill trained in special schools for that very emergency that the result is the protection of enormous investments, the perfectioning of products and a stop to the loss of trade.

In seeking for natural or historical reasons to explain the industrial development of this region, we will find in the first place that while this fair section of our planet has both hills and plains, it is washed and serrated by a generous supply of waterways, that these in turn are deep and that they terminate in bays of large extent, discharging voluminously into the ocean.

A properly drawn map will also show a great network of railroads approaching the center, running along the banks of these waterways, crossing them above, below, connecting and interconnecting. When to these natural advantages we add that of a commanding position as a port of entry, and one where articles of export can be most favorably taken on, we see that these are the overwhelming influences causing the growth. Civic pride directing the mighty forces to co-operate here has not at all been the agency for good that we might imagine—the great city has grown rather in spite of a deficiency of such pride. The historic significance of the early selection of this port for entry by the transoceanic vessel lines, the genius of DeWitt Clinton, the parallel powers of Alexander Hamilton, have frequently been recorded, but notwithstanding the existence of chambers of commerce, boards of trade and merchants' associations, few grand conceptions similar to Clinton's creation of the Erie Canal and Hamilton's foundation of a city on the Passaic and the utilization of the water-powers of that river, or similar to the introduction of the Croton water system into New York City in 1812 have been formed or brought about to completion.

Lack of perception between the States and among numerous municipalities that their interests were so intertwined as to be identical, have hampered great undertakings leading to expansion of manufacturers, and in many ways when these did not operate as inhibiting agents the evils of petty political manoeuvering did.

The writer proposes to show that if the great Metropolitan District just described could be included in a commercial zone to be covered by treaty in which the community of interest would be thoroughly recognized, for the improvement of waterways, raising of flooded land areas, the erection of docks, increase of water supply, tapping and introduction from a distance large supplies of fuel, gas or electricity, protection of certain areas against land exploitation in order that housing may be sanitary, salubrious and secure for the laboring man; all of these could be brought about without waiting for the haphazard development that comes with the urgency of demand. An enlightened and broad minded consideration of the rights of the 10,000,000 dwellers to be in this territory ought now to be taken up by those highest in authority and most able to bring about the good.

Let us consider how these great works came to grow. Many of them, such as the sugar business and chemical works, were in the very earliest history of the city used to meet the local demand of that territory. The first sugar refiners were the confectioners. The first hard refining was in the slaughter houses. The ... by shipping by the Erie Canal and the bringing of ... by rail and water determined that the refineries, ... and chemical works could increase, and the supply-... the world began. The greatest factor of in-... already mentioned was undoubtedly the ... of the Pennsylvania oil fields into this center by means ... pipe lines under ... length.

The offensive character of some of these businesses and the necessity for securing large areas of cheaper land than city lots gradually caused the establishment of factories in the meadow lands of the surrounding river valleys, and in many cases the works that had removed to a desolate spot became the center of a small city itself. Then improvements were made in processes which made even some of the most offensive innocuous and not in such wise undesirable.

Sites.—We find now the following situation as regards site and position: The Hudson River from Yonkers down to and opposite Riverside Drive has been taken up for park or ornamental purposes, which will exclude factories in the future. The city generally has such extraordinary demand for its docks for steamship and general city purposes that very little manufacturing will in the future be done immediately on Manhattan Island's waterfront. Brooklyn, Astoria, and a part of the Bronx shore will continue to attract manufacturers. South Brooklyn is particularly advantageously situated, although the land areas are not so large.

Staten Island, from the point of view of deep-water frontage and large inland areas, is an ideal situation and promises to continue the great growth which has been going on for a score of years. Perth Amboy, Bayonne, Elizabeth and Newark are rapidly assuming positions of importance in the establishment of large units of production of manufactures. Jersey City, Hoboken, Weehawken are old-established sites, improved nearly to their limits. Passaic and Paterson are desirable locations for manufacture of articles susceptible of carrying heavier charges for handling and calling for a large force of contented skilled labor.

The meadows skirting the shores of the Hackensack, Newark Bay and Passaic River have been left to the last because we considered it one of the most important of the local areas, and the one which will call in the future for the application of the most farsighted principles for development. These meadows extend from Elizabeth to Hackensack and are of the general width of four miles and are about 18 miles in length. There is an area of 37,000 acres involved. There are 12 important lines of railway crossing them. The improvement by filling and utilizing as solid land this great and almost unused territory is a dream which has fascinated many engineers and economists who see on the one side of it the great metropolitan city and on the other side other large cities growing toward one another until they appear to meet and form another unit which could almost be called a metropolis.

Admitting that one of the great reasons for the development of Manhattan Island was its beautiful situation, washed by swiftly flowing and broad streams on two sides, one finds in these other two rivers, the Hackensack and the Passaic, the promise of great advantage if only the low-lying bordering acres could be properly prepared for industry. Such an improvement was proposed in 1896 (Geological Survey of New Jersey, Report of State Geologist for 1866) by C. C. Vermeule, whose plans included a system of embankment and subsequent removal of the water by pumping.

This has never been carried out on exactly the same plan as proposed by Vermeule, but to some extent certain portions of these meadows have been improved by depositing upon the river mud and sand dredged by hydraulic dredges. The result is that at present an area of several hundred acres has been presented for use, none of which has yet been, however, improved by factory buildings.

The city of Newark interested itself in securing the deepening of the channel in Newark Bay to about the center line of the city. This improvement has just been consummated. The same city is also at work on a project of excavating further channels and a canal system bordered by bulkheads behind which the dredged material will be deposited, thus reclaiming an area of 3000 or 4000 acres.

Fuel and Power.

The great element of advantage to New York in the past has

been its proximity to the anthracite coal fields of eastern Pennsylvania. This valuable fuel was supplied in amounts of extraordinary tonnage and at prices which for a great many years during the early development of manufactures was extremely low. The appearance of the spectra of extinction of its valuable deposits has been one of the elements along with the high labor costs and high freight rates to bring about high prices for this coal delivered in New York City. The price has continued to increase until now steam sizes in large lots are from $2.50 to $3 per ton.

Bituminous coal is coming more and more into use in the outlying parts of this district where smoke consuming may not be so strongly enforced. The prices of this coal are on a par with anthracite. Of both kinds of coal the factory demand on New York Harbor points is about 2,500,000 gross tons annually.

With such fuel charges the cost of steam power would have risen to a damaging level were it not for a coincident improvement in boiler and steam engine practice. The need of large volumes of water for condensing has not been felt by any of the factories located on the tidal streams and bays. In the great railway power houses increased efficiency is being reported, and it seems as if extensive manufacturing establishments ought to acquire whatever of these advantages are not due to regularity of output and steadiness of load. The great losses from imperfect combustion and from unburned coal still continue to be viewed calmly by numbers of managers.

In the future new sources of power will probably be placed at their command, and inasmuch as the largest field for such power will be where manufactures are most concentrated, it is easy to see what could be promised for the district of New York and Newark and the meadows territory lying between.

In the first place we could consider the advantages of power gas. If gas were manufactured for a market at 40 cents, the residuals being produced on a large scale, the consumption for gas engines would warrant the establishment of such a works in a very large unit in the most desirable place in the center of the greatest consuming territory. With the improvements in gas engines, with direct-connected electric generators, the installation of large units intended for the production of power by power-gas is very promising.

Another source of cheaper fuel and power might be sought for in the utilization of the culm banks of the coal mines in the anthracite district, but whether this culm could be carried or floated to New York, or whether it should be gassified near the point of largest supply and the gas piped to New York, does not make such an important question, inasmuch as culm would appear to be an unreliable source and itself rising in value where it is produced.

The advance in producer-gas practice, so well known to you all, points the way clearly for economy to those works managers who can use the product to most advantage, and the adoption of the producer principle to ordinary furnaces promises still further economy of fuel.

Oil as fuel should continue to excite interest even at this point, 400 and 500 miles from the original source of supply of crude oil. The reason for this lies in the fact of an interesting change in the mineral-oil industry coming about through the rapid introduction of power vehicles and power boats. The great demand for gasolene caused by these has brought about such changes in refining that a larger yield of fuel oil is now obtained than formerly. As a consequence its value is as low as 2¾ cents per gallon. The Appalachian, the Lima and the mid-continental fields, with pipe lines to New York, and producing over 50,000,000 bbl. of oil from which from 20 per cent to 25 per cent of fuel oil can be obtained, certainly gives promise of a steadiness of supply, even if the demand should grow great.

The most fascinating promise of new power for this district comes from the hopes of the utilization of certain water-powers. The nearest is the power of the Passic River. It is proposed to establish reservoirs along this stream so that the present flow can be regulated and power obtained over long intervals, but at its best the maximum of power obtainable from this stream is only 12,000 hp, and it is already owned by the Society for the Establishment of Useful Manufactures founded by Alexander Hamilton and controlled by the East Jersey Water Company.

The next most valuable source is to be found in the Delaware River, in New York State; the next after that the water-powers of the upper Hudson River.

In an admirable report of the New York State Water Supply Commission on Water Storage and Power Developments, 1909, these are particularly well described.

In the case of the Delaware water-power, the following appears in the special report of the Engineer, in speaking of the improvement of the Delaware River between Cannonsville and Port Jervis, which could furnish 40,000 to 50,000 constant mechanical horse-power: "This 40,000 to 50,000 continuous hydraulic horse-power will generate, at 95 per cent efficiency of electrical machinery, from 28,500 kw to 36,600 kw, which, distributed under a 50 per cent load factor, and 85 per cent efficiency in transformation and transmission, would deliver in ordinary working hours a maximum of 65,000 to 81,000 electrical hp at the consumer's end."

He says "there is at present no nearby demand for anything like this enormous amount of power. The only adequate market from which returns might be expected is to be found in the thriving manufacturing cities of eastern New Jersey at an average distance of 90 miles. The industrial activity in many of the places within 15 miles of Jersey City, together with the rapid growth in population, and the constant extension of electric railways throughout this district hold out attractive possibilities for the sale of electric power."

But the most promising scheme is the development of the upper Hudson between Troy and Hadley, where horse-power is already developed, but where by systemmatic improvement 196,300 total horse-power could be developed, and as the distance from New York is not at all prohibitive for economical transmission, it would seem as if yet it would materialize. A very powerful agency for bringing this about in the future will be the concurrent improvement in the hydrographic situation which goes with this power improvement, namely, the prevention of floods with all of their accumulated evils.

Given a supply of electrical horse-power in this Metropolitan District under consideration, we could easily see how manufacturing for export of every variety of substances which can now be made the product of the electrolytic vat or the electric furnace will bring still larger industrial industries. And this mode of application of the current is the most promising one for the justification of these distant hydro-electric plants; inasmuch as the demand at an electrometallurgical works is not as exacting as that of an electric railway, because the volume of current demanded in the former permits of long-distance transmission with less line and transformation losses.

If the water-powers of the Passaic, the Delaware, and the Hudson were improved and utilized, thus in and near New York City the combined power supply and present manufacturing development of Niagara Falls, N. Y., and of Lowell, Lawrence and Holyoke, Mass., could be duplicated here and leave many thousands horse-power to spare. The politico-economic effect of such a concentration would be as interesting a study as that of its technological consequences.

Water Supply.

But a great want in the future will always be water supply. There are a few subjects which give the technical manager operating here more concern than this. Shortage of supply corrosion of boilers, incrustation or large water bills—some or all of these things afflict all but the most favored.

The point of view of the governing authorities in considering water supply is always, of course, first the question of the securing of a potable supply. But the factory manager gives attention also to the question of qualities for his purposes and of cost. A potable water supply would not always be as desirable

for, let us say, a dye house of a bleachery, as one which would not meet the views of the sanitarian for some pathological reason, but which really furnished a good and peculiarly desirable supply. But fortunately most often the most potable water of the large supplies is also equally the most desirable for technical use.

The great bugbear for the large steam users is the cost of water and if this could be reduced the advantage would be considerable and tend to prolong the contest of the steam engine against the gas engine. Water bills of $30,000 and $40,000 a year are not uncommon in the vicinity of New York.

In the district we have under consideration there is a great variety of water supplies.[1] . . .

If the States and the counties recognize no lines of distinction, the following would be the sources to be availed of in the future as a universal system.

Underground Long Island (Queens, Nassau and Suffolk counties).

The Bronx and Byram rivers.
Yonkers wells.
Staten Island wells.
Croton system.
Hudson River at Hyde Park.
Catskill and Esopus system.
Passaic River system.
Rockaway River system.
Hackensack River system.
Pequannock Valley system of Newark.
Perth Amboy wells.

If Brooklyn should draw all that is needed from Long Island; if Staten Island be allowed to draw from New Jersey and in return for this concession New York permit its Catskill line to be tapped at Cornwall for the supply of the territory under consideration, lying on the same sides of the Hudson, all groups and consuming centers and intercommunicating fields would be supplied with the maximum of economy, the minimum of further outlay and the maximum of technical and sanitary purity. But a cry of horror will go up from the New York City taxpayer when he is told of a proposition that contemplates giving advantage to residents of New Jersey of what shall have been acquired by him at a cost beyond his willingness at present to sit down and calculate. But this is just what he should do for his own financial salvation.

The Catskill project has been unwarranted by the facts.[2] . . .

In the prosecution of the Catskill project many difficulties have been met with, and very large additions to the estimated cost are now admittedly necessary. The difficulty of crossing the Hudson River has become increasingly great. The point at which it is now said the crossing is to be made is at Cornwall about 50 miles from the city. This aqueduct will thus have been brought to within 40 miles of the center of the district we are considering, or about 60 miles from Staten Island. To tap it there to go to New Jersey and Staten Island through the trans-Hudson River Valley is to open a market at once for surplus goods whose productions has cost too much to admit of neglecting any sale. . .

Let the whole territory be considered as a unit of interest. Every factory established in eastern New Jersey is an asset for New York City, and every dweller there a contributor to the wealth of New York City. Then when a population shall have grown up which consumes all of the present supplies and the Catskill supply, we shall still have the Hudson filtered water to draw upon and the Suffolk County supply. For 25 years before that time shall have arrived we will have been drawing a large income from the surplus Catskill water. We shall have been supplying to Staten Island in the most practical way what is difficult to supply across the Narrows, and we shall have been aiding to develop a fringe of New Jersey, which, by almost every right, is practically our own city.

Materials Supply.

There are many considerations not touched upon before which point to the correctness of any view which sees a great technical industrial future for the enlarged metropolis. Such would be the excellent supply of material—raw materials—coming by rail and by inland waters and from over seas, and general materials for supplies and repair being quickly obtained. This latter is a source of economy and makes for ease of mind of the factory manager. Such also is the favorable market for skilled and unskilled labor. Another great advantage is the ease of importation and the facilitation of customs business. Manufacturing in bond for export should develop largely in such a district.

We might give a moment's consideration to the observation of how peculiarly certain industries have passed the district by. We have, for instance, practically no iron industry. The last blast furnace, that at Secaucus on the Meadows, went out of blast a few years ago. An old-established rolling mill for structural material at Paterson went into the hands of a receiver about two years ago. Another of pretentious size and new equipment, designed to manufacture open-hearth steel and roll structural shapes, met with a similar fate during the panic. A wire-rod mill making its own open-hearth steel at Astoria several years ago went the same way. Several crucible-steel works, however, are operating and prospering continuously.

But there can be little question, and some good authorities interested in other districts have admitted it, that a blast-furnace plant and steel works for rail and structural shapes could, under proper conditions, be successful in this position. These conditions would appear to be the use of Cuban ore, as well as of Adirondack, Orange County, and New Jersey ores, the manufacture of by-products coke, the utilization of the gases of both coke ovens and blast furnace, and a continued supply of scrap. It is possible that the reduction of the duty on iron ore may help to bring about such a project to realization. At any rate we are almost certain to see with the introduction of electric power the establishment of a considerable number of electrical steel furnaces.

Paper manufacture does not exist, if we except certain paper-board manufactories, and it is not likely to be established. There is no manufacture of cement, and there is not to be any though we may see clinker ground on a large scale and distributed in the surrounding country in bulk.

With this review we may dismiss our subject, but not without expressing a hope of seeing industrial happiness here continue and increase. Because that man is most blessed who is industrious, that city is happiest which has the greatest proportion of contented workers. Our best monuments will not be pleasure palaces, but healthful factories, comfortable homes, cheerful and beautiful buildings, called for by the highest aspirations of a people living by toil, but neither exhausted nor hopeless.

Therefore, to lead this district to its best development is an accomplishment of the highest abilities in constructive statesmanship and practical economics.

Conclusions.—Enough has been said to indicate the truth of the following propositions:

1. The territory described and recognized as the great Metropolitan District is destined to be a most interesting technological center by reason of the establishment within it of the largest works in the world treating raw materials for the production of staples.

[1] Dr. McKenna gives in his paper a very full review of the various water supplies of the different sections of the metropolitan district. He points out the very serious situation in Staten Island; also almost equally urgent in the consideration of the water supply of the metropolitan district in New Jersey, where some of the water companies are close to the limit of their resources. "A solution of the difficulty for New York in its Staten Island supply and for New Jersey in its eastern cities supply, is to be found in the eradication, by treaty, for this if for no other purpose, of the State line of demarkation."

[2] The reasons for this criticism are given at considerable length in Dr. McKenna's paper. They are chiefly that the estimates of the population and of the per capita consumption were reached in a faulty manner and are both too high; further, that other supplies (for instance, Suffolk County) were available.

2. Its advancement would be more rapid if certain extensive improvements were made under some form of convention eliminating the disadvantages of separate State control.

3. A universal project for water supply is the most important of these improvements.

4. Reclamation of large sunken areas adjacent to deep water to adapt them to normal uses of land is the next most important improvement.

5. Introduction of electric power from the nearest large hydraulic conservation works in both States is an improvement which gives promise of most extraordinary advantages, particularly for electrochemical and electrometallurgical development similar to that at Niagara Falls.

The Estimation of the Temperature of Copper by Means of Optical Pyrometers.

BY G. K. BURGESS.

The experiments here described are a part of a proposed series of determinations of such thermal properties of materials* at high temperatures as are of considerable technical interest.

The measurement of the temperature of inaccessible masses of hot metal, whether liquid or solid, is of prime importance to the metallurgist, and it is generally recognized that an optical or radiation pyrometer sighted upon a clear surface of liquid metal, such as iron and copper, indicates too low a temperature if the pyrometer has been calibrated in the usual way in terms of the radiation from an enclosure approximating a black body.* It was in order to furnish the data needed for an approximately correct estimate of the temperature of liquid and solid copper by means of optical pyrometers using monochromatic light and by means of pyrometers using total radiation, that the following experiments were undertaken. Some preliminary observations have also been made on iron, but further work has been postponed until the greater facilities of the new heat laboratory, now in the course of erection, are available. It is also hoped to make similar measurements on aluminium, brass, bronzes, and special steels.

It is a very difficult matter to determine accurately by any method the true temperature of the surface of a mass of metal, although in the case of metals which are good conductors and at the same time poor radiators, as is liquid copper, the uncertainties are reduced to a minimum.

As what is generally desired, however, is not the temperature of the surface of the metal, but of its mass as a whole, this difficulty is of minor importance, since the corrections to the optical pyrometer sighted on the surface may be given so as to reduce its readings to the temperature at some definite region within the mass of the metal.

A complete experimental study of the temperature distribution within a considerable bulk of cooling copper has not as yet been undertaken, but a preliminary attempt is here made to determine, to a degree of accuracy sufficient for most technical needs, the relation between the readings of the two types of radiation pyrometers above mentioned and those of a thermocouple whose junction is placed just beneath the surface of the metal.

Arrangement of Experiments.—The experiments were carried out in a darkened room during September and October, 1908, using an American Gas Furnace Company's No. 3 melting furnace for melting the copper, which was contained in shallow crucibles, both magnesia and graphite of 8 cm inside diameter. With the cover of the furnace removed the gas and air supply could be so regulated that either a clear copper surface or one of oxide could be obtained at will on the liquid copper, the crucible being so set in the furnace that the flames did not play directly on the metal surface in line with the axis of the optical pyrometer. The crucible was set so high in the furnace that radiation from the inside walls of the furnace could not be reflected into the pyrometer, which was pointed at the copper surface at an angle of 25° to 30° deg. with the vertical.

In the case of the rough oxide surface, diffuse reflection from the furnace walls may affect the optical readings, especially if the walls are hotter than the oxide surface. This effect was shown to be small, in the experiments where monochromatic light was used, by changing the height of the crucible in the furnace; but it becomes serious when using the whole spectrum.

When sighting on the pure copper liquid surface, which forms a mirror, there is only specular reflection from bright objects to contend with, and in this case the metal may be at the bottom of a deep furnace and no error can arise from reflection from furnace walls or other incandescent sources unless they can actually be seen in the pyrometer telescope.

In order to measure the true temperature of the layer of copper immediately beneath the surface, the thermocouple was enclosed in a thin porcelain tube bent into the form of a crook in the tip of which was placed the junction of the couple. This method of introducing the thermocouple had the advantage of leaving virtually the whole surface of the copper open to the view of the optical pyrometer, beside eliminating any error in the temperature readings arising from conduction along the thermocouple wires

The Pyrometers.—The temperature readings of the platinum, platinum-rhodium thermocouple were taken with a Siemens & Halske pyrometer galvanometer of 400 ohms resistance. The optical pyrometer used was of the Holborn & Kurlbaum type, using the Morse principle of disappearing lamp filament, although the results obtained apply equally well for any type of optical instrument using the same red-colored light, such as the Wanner and Féry-Absorption pyrometers, and the Morse Thermogage, when the last is provided with a suitable red glass between the lamp and eye, as in the Holborn-Kurlbaum instrument. There will still be a small correction, however, for the slightly differing reds used in these various instruments. In order to bring out the effects of selective emission in the radiation from copper, measurements were also taken with green glasses in place of the red between the eye and the pyrometer lamp. The total radiation instrument used was a Féry reflecting telescope with gold mirror. It is probable that other total-radiation pyrometers would give results differing slightly from those found here, and even two Féry instruments would probably not give identical results.

All the instruments used were calibrated in terms of the standard temperature scale, on which the melting points of pure zinc, antimony and copper are taken as 419° C., 630.5° C. and 1084° C. respectively. The temperature of the copper freezing point is lowered by the presence of cuprous oxide, and, in a gas furnace, unless a reducing atmosphere is maintained, the copper usually begins to freeze out on cooling at temperatures between 1075° C. and 1080° C. That the thermocouple, whose junction was just beneath the surface of the copper, was really indicating a temperature not far from the true temperature of this free surface of metal, was evidenced by the fact that, as the crust began to form, the thermocouple never read higher than 1080° C. and usually within 5° C. of 1075° C.

Measurements With the Optical Pyrometer.

On Clear Liquid Copper.—To a sufficient degree of accuracy for all practical purposes, the relation between the apparent temperature of the clear surface of the metal free from oxide as given by an optical pyrometer using monochromatic light and the actual temperature of this surface is linear.

For liquid copper possessing a mirror surface free from oxide and haze, we find the following equations to hold for red and green light, respectively:

$$\text{Red light } (\lambda = 0.65\mu) \quad t = 1.515\,r - 359 \qquad (1)$$

$$\text{Green light } (\lambda = 0.55\mu) \quad t = 1.515\,g - 477 \qquad (2)$$

where t is the true temperature centigrade of the copper and

*See "Optical Pyrometry," C. W. Waidner and G. K. Burgess, *Bul Bureau of Standards*, I, p. 189, 1905; and B. S. Circular No. 7, "Pyrometer Testing and Heat Measurements."

and D the apparent temperatures given by the optical pyrometer using red and green light, respectively. It will be seen that at the melting point of copper, the pyrometer using red light reads 130° C. too low, and that the apparent temperatures with green light are higher than those with red light by a constant amount over the whole temperature range, namely, by 78° C.

The precision attained in these measurements is shown in Table I, in which the computed temperatures satisfy equations (1) or (2).

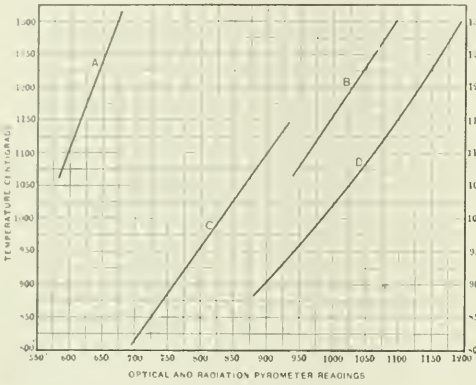


PLATE I.—TOTAL RADIATION PYROMETER CURVES, A AND C. OPTICAL PYROMETER CURVES, B AND D.

(A and C refer to molten copper; A and D to cuprous oxide.)

Table I.—Temperatures of Molten Copper with Optical Pyrometer.

With red glass: λ = 0.65 μ. Temperature centigrade. Computed.	Observed.	Comp.-Obs.	With green glass: λ = 0.55 μ. Temperature centigrade. a. d. of a single obs. = 3° C. Computed.	Observed.	Comp.-Obs.
1073° C.	1077° C.	4	1082° C.	1087° C.	−5
1078	1078	0	1083	1087	−4
1078	1075	0	1092	1101	−9
1078	1081	−6	1107	1104	+3
1077	1075	+2	1115	1110	+4
1085	1085	0	1154	1153	+1
1085	1081	+4	1154	1141	+13
1085	1096	−11	1159	1172	−13
1090	1079	+11	1159	1159	0
1090	1093	−3	1182	1188	−6
1090	1096	−6	1187	1195	−8
1094	1096	−2	a. d. of a single obs. = 6° C.		
1094	1098	−4			
1114	1118	−4			
1121	1117	+4			
1129	1129	0			
1133	1131	+2			
1145	1145	0			
1147	1148	−1			
1157	1155	+2			
1159	1160	−1			
1185	1185	0			
1208	1212	−4			

a. d. of a single obs. = 3° C.

In deducing equations (1) and (2), a slight allowance was made for the fact that the optical readings would tend to be high, due to the slightest impurity on the copper surface.

On Cuprous Oxide.—When the copper freezes or when an oxide coating forms on the liquid, the readings of the optical pyrometer are higher than when sighted on the pure metal. For a thin coating of oxide floating on the liquid the optical pyrometer using red light reads approximately 100 deg. C. higher than when sighted on the clear metal. When green light is used, the change from metal to oxide increases the apparent temperature by only about 35° C., indicating the relatively greater intensity of the green in the light emitted by liquid copper. This greenish appearance persists in incandescent solid copper, as may be seen by adjusting the gas feed, to remove the surface oxidization.

Corrections to Optical Pyrometer Readings.—Table II and plate I give approximately the true temperatures in terms of

Table II.—Temperatures with Optical Pyrometer.

(Red light λ = 0.65 μ.)

Liquid copper— Pyrometer reading.	Temperature centigrade.	Cuprous oxide— Pyrometer reading.	Temperature centigrade.
950	1062	900°	903°
975	1118	950	958
1000	1156	1000	1020
1025	1193	1050	1087
1050	1231	1100	1159
		1150	1233

the indicated readings of optical pyrometers using red light when sighted upon either the clear copper or the oxide. It will be noticed that for the oxide, the relation between the optical readings and the true temperature is not quite linear. If the liquid surface is hazy, encircled by flames, or only partly oxidized, the optical readings will lie somewhere between the two curves *B* and *D*.

Measurements with Total Radiation Pyrometer.

The measurements of surface temperature by this method are much less satisfactory than with the optical pyrometer, since slight changes in the properties of the surface produce a much more marked effect on the readings of an instrument using the whole spectrum, visible and invisible, than of one using only a narrow spectral band.

With the Féry pyrometer used in these experiments the difference in reading at the melting point of copper, when sighted, first, on the clear copper and then on the oxide, was from 275° to 300° C., and the apparent temperature of freezing as given by the Féry instrument sighted on the clear liquid was slightly less than 600° C., instead of 1075° C. or 1080° C., as given by the thermocouple, so that, according to the condition of the copper surface, the corrections to the readings of this instrument lie between 480° and 175° C. at the copper melting point. Even a very slight haze or fog over the copper surface will cause a rise of 25° or 50° in the Féry reading and the presence of flames will change the readings by amounts uncertain both in quantity and direction. The depth of the crucible in the furnace and the effects of radiation from the furnace walls also influence the readings considerably, unless the copper surface is absolutely clear.

The readings of the Féry pyrometer in terms of true temperature, both for the clear copper surface and for the oxide surface, are given in plate I, lines *A* and *C*.

These observations satisfy the following equations:

Liquid copper: $t = 3.55\,F - 1018$,

cuprous oxide: $t = 1.41\,F - 169$,

where t is the true temperature centigrade and F the reading of the Féry pyrometer.

Emissivity of Copper and Cuprous Oxide.

The results obtained from the temperature measurements on liquid copper and cuprous oxide may be expressed in terms of their emissivity, that is, by the ratio of the intensity of radiation, either monochromatic or total, for each of these substances, to the corresponding intensity of radiation of a black body taken as unity.

For monochromatic light, we have, for the emissivity, e_x of a substance:

$$\log e_x = \frac{14500}{\lambda} \log \epsilon \left(\frac{1}{T_x} - \frac{1}{T_b} \right)$$

where the subscript x refers to the substance under investigation and b to the black body, λ is the wave-length of the light used, T is absolute temperature and ϵ the naperian base of logarithms.

For total radiation, the emissivity, E_x, is given by:

$$\log E_x = 4\,(\log T_x - \log T_b).$$

These quantities are given in Table III for both copper and cuprous oxide. Thwing* also finds $E_x = 0.14$ for molten copper with his total radiation pyrometer sighted on a stream of the metal.

*C. B. *Thwing*: On the Emissivity of Molten Iron and Copper. Phys. Rev. 26, p. 190; 1908.

Table III.—Emissivity of Liquid Copper and of Cuprous Oxide.

Liquid copper				Cuprous oxide			
Temperature centigrade.	ϵ_μ for: λ=.65 μ.	λ=.55 μ.	E_μ.	Temperature centigrade.	ϵ_μ for: λ=.65 μ.	λ=.55 μ.	E_μ.
1075 ..... 0.17	0.47	0.16		800	..	..	0.66
1125 ..... .15	.38	.15		900	..	..	.66
1175 ..... .14	.32	.15		1000 ..... 0.80	..	..	.56
1225 ..... .13	.28	.14		1100 60	0.68	..	.54
1275	..	.13		1000 ..... (.49)	(.49)	..	..

These experiments were carried out with the able assistance of Mr. J. J. Crowe.

Bureau of Standards, Washington, D. C.

The Formation of Silicon Sulphide in the Desulphurisation of Iron.*

By W. Fielding

The object of the work was to investigate the conditions under which ferrosilicon can react with ferrous sulphide and liberate a sulphide of silicon.

In the refining of steel in the electric furnace a very complete desulphurization of the metal can be effected. This action is in practice found to be considerably facilitated by the addition of a charge of ferrosilicon.

Several explanations have been put forward to account for this influence on the removal of sulphur. Some have ascribed it to the high temperature produced during the reduction of the ferrous oxide present by the ferrosilicon. Professor Osann (*Stahl und Eisen*, July 15, 1908; this journal, Vol. VI, page 406, 1908) believes that this removal of iron oxide prevents the back-action between it and calcium sulphide; at the same time a higher temperature is produced by the deoxidation which assists the removal of sulphur as calcium sulphide. At the end of his paper he suggests the possibility of the formation of a gaseous compound, silicon sulphide.

Max Haff (Electrochemical and Metallurgical Industry, March, 1908, page 96) has previously declared that silicon was produced by heating together sulphides and silicides at a high temperature, but no details were given of his experiments. Silicon sulphides (SiS_2) is described (Hempel and v Haasy) as a solid at ordinary temperatures, which at a red heat sublimes under 60 mm pressure.

In the present work the reaction between ferrosilicon and ferrous sulphide was investigated by heating intimate mixtures of these compounds in a vacuum at known temperatures. The reacting substances were placed in a crucible in the form of a hollow graphite rod, which could be evenly heated by the passage of an electric current. Electrical connection was made with the rod by fitting it in graphite plugs, which in turn were soldered into water-cooled brass tubes to which cables could be attached. (Compare Pring and Hutton, *Trans Chem Soc* 1906, Vol. 89, page 1593, and H. C Greenwood, *Trans. Chem. Soc.*, 1908, Vol. 93, page 1485.) The rod was surrounded by a water-jacketed Jena glass tube, for experiments in which the rod was heated below 1500° C.; above this temperature a silica tube was employed. The apparatus was made air-tight by luting the ends of the tube with soft wax. Temperature readings were made by means of the Wanner optical pyrometer in those cases in which a glass tube was employed, and changes in pressures were indicated by a mercury gage connected with the tube.

In experiments in which the commercial variety of iron sulphide was used, the mass fused at a temperature of about 930° C., and a vigorous reaction set in with rise of temperature. In later experiments, using pure iron sulphide (free from oxide) no reaction was observed up to about 1300° C., hence the reaction noted in the first case was probably due to reduction of oxide of iron present in the iron sulphide by the ferrosilicon. This explains the sudden rise of temperature noted.

In all the experiments a yellow sublimate began to appear on the walls of the tube at a temperature of 1500° C. On removing this product and treating with water, a rapid efferescence took place, sulphuretted hydrogen being liberated and silica separating. A larger quantity of this product was prepared by placing a mixture (40 gms) of ferrosilicon and ferrous sulphide in a long graphite tube, which was closed at one end and fitted at the other into a porcelain tube to serve as condenser. The graphite tube was then placed in a horizontal carbon-tube furnace, with the porcelain tube projecting outside, and the temperature was raised in stages.

No sublimate was formed until a temperature of 700° C was reached (the higher temperature required in this case being probably due to the experiment being carried out at atmospheric pressure instead of at reduced pressure as before) when a yellow vapor was evolved, which condensed partly in the tube, the remainder being carried along by the stream of carbon monoxide gas coming off, which on being burned on the end of the tube smelled strongly of sulphur dioxide.

About 4 grams of the product were obtained, which, on analysis, was found to consist of approximately 50 per cent silicon sulphide (assuming the formula to be SiS_2) the remainder being iron sulphide, which had volatilized, silica (obtained from the action of moisture in the air on the silicon sulphide) and a small amount of ferric oxide is a finely divided state. In different experiments products of variable composition were obtained.

The silicon sulphide was estimated by acting on it with water in a Schrotter's apparatus (fitted with a calcium chloride drying tube) and determining the weight of sulphuretted hydrogen evolved. The gas evolved, after being efficiently dried by calcium chloride, was passed into weighed potash bulbs, and the increase of the potash was found to correspond to the lossing weight of the Schrotter's apparatus. The weight of silicon sulphide (SiS_2) corresponding to this weight of sulphuretted hydrogen was then calculated. The product remaining in the apparatus was then treated with dilute sulphuric acid, and the gas evolved driven over into weighed potash bulbs, and the corresponding amount of ferrous sulphide calculated. The estimation of the ferrous sulphide was further confirmed by determining the amount of iron present in the solution, which was found to correspond to the amount of iron sulphide present.

It will be observed that it has not been possible to fix the identity of the sulphide of silicon present in the product. An attempt was made to prepare the silicon in greater purity by distilling the product in vacuo, but up to 1100° C. no volatilization was observed. No attempt was made at higher temperature, as iron sulphide is also volatile above 1100° C. According to Hempel and v. Haasy silicon sulphide (SiS_2) distils at red heat under 60 mm pressure; this tends towards the conclusion that it is a much less volatile sulphide of silicon which is here produced.

*Paper read before the Faraday Society on June 15

The Utilization of Low-Grade Fuels in the United States.*

By Dr. O K Zwingenberger

The United States Fuel Testing Plant at St Louis and its branch at Pittsburgh have certainly rendered a great service to this country in inducing people to pay more attention to the economical utilization of coal. Much talk was heard in the last years that the exhaustion of the fuel supply would be in sight already in some few decades and that a general revolution of both our industrial and public life certainly was to take place. But revolutions do not come suddenly like lightning from heaven; they are all prepared in time, and the revolution to come in industrial life is very well taken care of by the scientific men of the Geological Survey, who are in charge of the fuel testing plant.

The work in the estimation of coals for combustion under the boiler and for utilization in the gas producer has been of great

*A paper read at the Brooklyn meeting of the American Institute of Chemical Engineers, June 24, 1909. Slightly abstracted.

benefit to the development of the industry as is seen by the eagerness with which the gas producer and the gas engine have been taken up in recent time. The gas producer was especially given much attention at St. Louis and Pittsburgh. Nearly all the gas producers in this country are run on anthracite, charcoal and coke, though attempts have been made to construct suction gas producers which can be operated on bituminous coal and lignite.

The United States Geological Survey tried out at St. Louis all kinds of materials down to lignite and peat by boiler tests and gas-producer tests. Though the results were most satisfactory ones, the inducement thus presented to the people in regard to the latter materials were generally overlooked and are not yet made the basis of industrial enterprise, though the future of these materials appear a most promising one at closer inspection.

To low-grade fuels much attention has already been paid for many years in Europe, where, in central Germany and in Scotland, a highly developed industry for the dry distillation of lignite or brown coal and bituminous slate is established. However, those industries were originally not founded to get the fuel contained in this material, but more for the recovery of by-products, and, for instance, in the distillation of brown coal the resulting coke was regarded almost a nuisance as with its disintegrated form difficulties were found in burning it up in the stoves. It was only by the construction of special stoves that the situation of this industry was reversed and the coke was made the main product.

The condition in regard to distribution of the fuel supply abroad is much different from the American conditions, and the people have to look more around to make the best of the raw material available at their location, and therefore many efforts were made to utilize the experience obtained in the distillation of lignite, also in other fields, as, for instance, in the coking of peat.

Peat is a pretty poor stuff in the eyes of many people, not worthy to deserve the least consideration. One cannot deny that there are difficulties on account of the high content of water, which in the crude state goes from 85 to 90 per cent. The drying of this raw material is a serious job on account of the handling of great volumes and the enormous quantities of water which have to be evaporated at the least expense, for which one has to rely mostly on the sun and air. That the drying of peat on a large scale can be done is proved in several instances, and success will be attained as long as carried out with the full attention and severe control of a business man. But this has not always been the case, and especially in many cases this apparently so easy business has been made the object of a stock-jobbing scheme.

That success is possible is shown by the peat coke[1] produced in one of the German works using the process of Mr. Martin Ziegler. It is as hard as any other coke. In its chemical composition it is entirely equal to charcoal, which to replace in nearly all cases it is the most suitable stuff, owing to its hardness. The cost of production of one ton of this coke is about $2 to $2.50. The by-products, which are obtained, are the same as in the distillation of wood, though in somewhat different quantities, and besides these there are some by-products which are obtained in the distillation of brown coal or lignite.

The two materials, lignite and peat, are already extensively used for many years to run gas producers in smelting works, glass factories, pottery works, etc., and though the use of peat is, of course, not such a large one, its use for gas-producer work is very well established by quite a number of plants. This is especially seen from the fact that in the province of Schleswig-Holstein a central gas-power plant is erected to supply electricity to 60 communities lying within a circle of 16 miles, and the whole power necessary is to be furnished by gas coming from gas producers entirely run on peat.

[1] A sample of this peat coke was exhibited at the meeting.

The use of low-grade fuel in the United States is still a very small one, and this fact is due to the distribution of fuel in the United States. In the East there is the anthracite and the bituminius coal; in the West and South the oil, and at many other places there is a good supply of medium coal, anyhow. Moreover, paraffin, lubricating oils, etc., are obtained in the easiest way and in much larger quantities by the distillation of mineral oil, so that it would be senseless to advocate a special coking process for lignite down in Texas, where the by-products of lignite, as paraffin, hydro-carbon oils, etc., would have deadly competitors in the oil and the by-products derived therefrom.

It is, therefore, undisputable that the use of lignite, for instance, in Texas, cannot be developed along lines which have already proved successful at other places, and as the chemical recovery of by-products from lignite is better not attempted, the solution of this problem is either briquetting lignite or gasifying it. For fuel there is always demand, and the gas derived from lignite is as good as that from anthracite, and it can be produced at an extremely low cost, so that it can compete with any material, also water and oil, for power purposes.

What is said about lignite holds also good for peat. States like Texas, Dakota, and Montana, which have enormous supplies of lignite, and the New England States and Minnesota, and Michigan, which have large deposits of peat, are much interested in the question of low-priced power. Owing to the necessity of transporting the power over great distances, cheap production of power is of the utmost importance for the development of those States, and the question whether these States have such a cheap source of power may be answered in the affirmative, as we only have to apply to lignite and peat the experience which is already available from the utilization of these materials at other places.

Here I wish to say some words about a wrong way in which it was very often tried to coke peat or lignite and which never leads to any success, as the resulting coke always will turn out in a disintegrated form. One has to consider that *lignite* in the state it comes from the mine carries a content of water from 25 to 40 per cent, and peat in its natural air-dried state has such a content of 25 per cent. It was very often tried and caused the loss of a great amount of money, to coke peat in a furnace which in its dimensions is pretty near the Hoffman-Otto oven, which is very long, has a height of about 2 yd. and the width of about 20 in.

Now what will take place if one puts a material with such a high content of water into a furnace which, according to its dimensions, is evenly heated all over its surface and the temperature of which is generally pretty high, a temperature of about 1000° C. generally prevailing in the inside? When such a coking chamber is filled the water in the raw material is subjected suddenly to evaporation and this development of steam is so vehement in its power that such a brick of air-dried peat or lignite unfailingly must be blown to pieces.

FIG. 1.—LAYER FORMATION IN COKING CHAMBER.

Furthermore, the material shrinks very much, so that after a certain time the upper part of the coking chamber would show up a hollow space and the heat conduction would be very poor so that the output would be very low in quantity, and a considerable time would be required. After a certain time one has, therefore, to fill in a new charge of raw material, and even this second charge would still leave after a certain time a little hollow space which one has to fill up again. It will then happen that when the lowest layer will be entirely coked, the middle layer will be only in a half finished state, and the upper layer in its first state of carbonization. (Fig. 1.)

This proves clearly enough that a horizontal retort of moderate height hardly will be a convenient apparatus for coking raw material of such qualities as represented by peat and lignite, and the upright retort is then left as the only means to

carry out successfully a coking process for this stuff as it has been used, for instance, for a long time in the distillation of lignite, and the furnace used in this industry was later on adopted and greatly improved by Mr. Martin Ziegler for the distillation of peat. (Fig. 2.)

The special feature of his process is the heating of the retort from outside from two independent fireplaces; the lower one gives the chamber the inside temperature of at least 1000° C., and the upper fire furnishes an inside temperature of about 600° C. As the heating is, anyhow, not carried to the utmost top of the retort, the incoming peat meets by radiation of the heat only

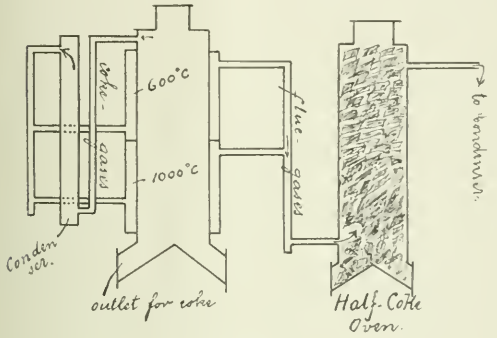


FIG. 2.—ZIEGLER PROCESS.

a moderate temperature. As from the retort, in intervals of one hour, peat coke is drawn off and fresh material is filled in at the top, the material goes down to the bottom, step by step, and passes from the moderate temperature through the medium temperature and at the bottom it is subjected to a high temperature and the effect of such a system is resulting in a material keeping the original structure in which it was introduced to the coke chamber, though, of course, somewhat reduced in size by shrinkage; the coke does not break so easily, and, it may be stated furthermore, that 95 per cent of the material comes out in the form in which it was introduced.

The gases produced in the coking process are passed through a condenser to solidify the tar, etc., and then the retorts are heated from the outside with this gas, and as the supply of air with gas heating can be very accurately regulated, the outgoing flue gases are practically free from oxygen and have a pretty high temperature. Mr. Ziegler has constructed a special furnace which he fills with peat and to which he introduces these flue gases directly and lets them pass over the peat. The temperature of these flue gases is high enough to entirely carbonize the peat and deprive it of the volatile matter and the resulting peat coke is, of course, not so hard as that coming from the retort ovens, but is still hard enough to stand transportation and handling, and to equal average coal in any way.

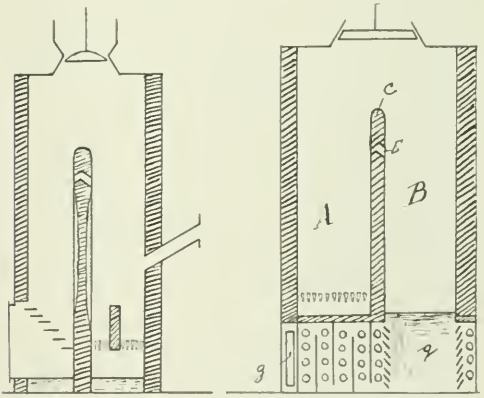
The following table gives the comparative analysis of peat coke, charcoal, and the lower grade of peat coke, which may be called half-coke:

	Peat coke.	Charcoal.	Half-Coke.
C.....	87.8 per cent	87.6 per cent	73.89 per cent
H.....	2.0 " "	3.1 " "	3.59 " "
N.....	1.3 " "	0.4 " "	1.49 " "
O.....	5.5 " "	4.7 " "	14.52 " "
S.....	0.3 " "	0.3 " "	0.20 " "
Ash	3.2 " "	0.9 " "	2.50 " "
Water	0.0 " "	3.0 " "	3.80 " "
B.t.u.....	14,500-800	14,500	12,100

There is hardly any difference between peat coke and charcoal and the figures for half-coke are good enough to stand the comparison with any good average coal. Now this successful experiment of Mr. Ziegler is of great importance with respect to the rational utilization of lignite and peat under American conditions. By combining a gas producer with a coking chamber, and a material change in the conduct of the gases, we are able to find a convenient form and the results of the combination of gas producer and coking chamber will, for two reasons, still be much better than Mr. Ziegler's half-coke furnace. I refer to a gas producer patented by me, which, with some change, permits the operation of this process. (Fig. 3.)

The gas producer is provided within its combustion chamber with a transverse partition which terminates at some distance below the top. This partition is diminished in thickness at the middle portion and is provided in its upper, thicker portion with transverse channels, and an inclined step grade is arranged at one side of the partition to which air may be supplied under pressure by the means of a supply pipe, the air passes to the fuel through the step grade after the fuel is ignited.

All the gases and tarry substances generated by the burning fuel go through the channels and over the partition into the other space opposite the partition where the fuel is dried and carbonized by the high temperature in the chamber. The gases, the tarry substances, and the steam pass through the high column of glowing fuel, so that the tarry substances are decomposed, while the steam acts on the glowing carbon. The heat generated in the chambers on both sides of the partition by the



FIGS. 3 AND 4.—ZWINGENBERGER GAS PRODUCER. (*g* EXIT FOR GAS, *q* OUTLET FOR COKE.)

combustion of the fuel over the grate is sufficient to reduce the carbon dioxide to carbon monoxide while passing through the glowing zones; the fire-bridge on the plane-grate serves for enlarging the glowing zone.

By this transferring of the tarry matters into permanent gas and the reduction of carbon dioxide into carbon monoxide, the quantity of produced gas must considerably increase, and on account of the greater content of hydrocarbons the heating value of the gas must be greater.

The efficiency of the present gas producer for peat as it is run in Europe is already a very satisfactory one. There is a great number of such gas producers running in Sweden and in Germany. In the latter country there is one, at Scheleken, erected by Mr. Ziegler, which burns up per hour 900 kg, or 1980 lb., of peat, furnishing 2500 cbm gas of 1200 calories, and as for 1 hp 2½ cbm of gas per hour is required this producer would run a gas engine of 1000 hp, but only the smaller part of the gas is used for power purposes and the main part is used in any open-hearth furnace, and on account of the absence of sulphur in the flame, the steel is of an excellent quality.[2] This producer at Scheleken works with recovering the by-products and has a condenser attached to collect the tar and the water; a

[2] This steel plant is now being largely increased. See Transactions of American Peat Society

great quantity of ammonia is obtained in the form of ammonia sulphate, approaching about 50 per cent of the theoretical value.

The gas producers for lignite and peat all separate tar and sometimes in considerable quantities, according to the size of the producer. This tar is of poor quality and has only a low money value; it is, furthermore, a troublesome nuisance as it is the source of pre-ignitions in the gas engine and of plugging the piston in the cylinder. These troubles are sometimes so obnoxious that they have already caused, in one case, the closing of a 20,000-hp plant operated with lignite.

The condensing apparatus makes the initial cost of the producer relatively high, and the cost to run such a by-product plant in connection with a gas producer is also pretty high since the absorption of ammonia by the sulphuric acid and the concentration of the solution needs good attention and the pumping of sulphuric acid onto the top of the tower is troublesome, too. At remote places, as in Texas, Montana, North Dakota, etc., the question of freight of sulphuric acid is already an item of consideration and another one is the question of labor. At remote places only such apparatus are useful which by their construction and operation guarantee the possibly greatest freedom of disturbances.

It may, therefore, be positively said that only big power plants run on low-grade fuel should work with recovering the by-products and that such plants under 1000 hp to 1500 hp better drop the by-products at all (provided there are not exceptionally favorable local conditions) and adopt a gas producer working up all the fuel to gas by transforming the tar into volatile matter.

A reliable producer transforming all the fuel into gas is certainly the ideal apparatus for places where either lack of time or local conditions do not allow to bother with relatively little quantities of tar and a moderate quantity of ammonia which hardly pays the expenses.

The construction of such a gas producer depends on combining in it the features of coking with that of the gas producer. My gas producer, as described above, is designed on such lines and in its new form allows the production of a much better gas than is generally obtained in the old-style producer.

The change, as shown in Fig. 4, consists in dropping the second grate and in extending the second chamber *B* down to the bottom and making it in this way like a coking furnace, and it furnishes also coke. Whereas in the gas producer the exit for the gases is at the side, the gases leave the new coking furnace by quite another way, for the exit of the gases is now located in the lower part of the partition. The chamber *A* is run as a general gas producer; the gases leave over the partition *C* and through the channels *E* into the chamber *B*, where, in the upper part the volatile matter of peat or lignite is driven out and the material is going to be carbonized and the heat of the gases is great enough to entirely carbonize the material. It is to be remembered that in the old-style producer the tar is distilled off by the hot up-going gases and is transported by them directly into the scrubber, where it is not sufficiently removed by water. In my construction the part of the chamber *B* directly adjacent to the combustion zone of chamber *A* is so hot that the material is glowing to transform the tar into gas and to reduce CO_2 into CO.

If we let chamber *A* go somewhat hotter, as is usually done with the gas producer, and approach somewhat the Dellwik-Fleischer process to blow in air regardless of a higher result in CO_2 we will get in chamber *A* a great combustion zone of high temperature, and we will have in chamber *B* a temperature of 1000° C. that the action of water on glowing carbon will go on in full extent as in the water gas producer, and besides that the CO_2 will reduce to CO when entering this hot zone. Of course, a part of the hydrocarbons of the volatile matter will be split up by this high temperature.

The special construction of this coking chamber admits of a feature which is generally difficult to combine with a coking process, namely, the cooling of the resulting coke and gas by water with recovery of the heat contained in the glowing coke. There is a system of water tubes; the coke in sliding down will give a considerable part of its heat to the water in the tubes and by partitions the gas is made to pass a certain way along these tubes in order to finally reach the exit. The shutters are for the protection of the water-tubes against pressure, poking, etc. The system of water-tubes is built to form a kind of boiler or evaporator to supply steam to the chamber *A*, if this is to operate as a regular producer.

Now we come to the most interesting question as to the cost of the hp-hour produced from the gas turned out by this coking oven.

In the old-style producers, like that at Scheleken, 1 ton = 2200 lb. of peat gives about 2500 cbm = 87,500 cu. ft. gas of 1200 calories = 135 b.t.u. per 1 cu. ft.

Of such gas a gas engine consumes about 90 cu. ft. for 1 hp-hour, so that we get 87,500 : 90 = 972 hp-hours.

For the gas-producer process we do not need to make fine bricks of about 10 in. length, and 3 in. by 3 in. square, but loose crumbles dried simply on the open air, put in calculation at the price of $1 per ton, will do, so we get, therefore, as to fuel cost for 1 hp-hour 100 : 872 = 0.115 cent. In the Ziegler coking process 1 ton of peat with 25 per cent of water gives in the average 26 per cent gases, weighing 1.104 gram per liter. One

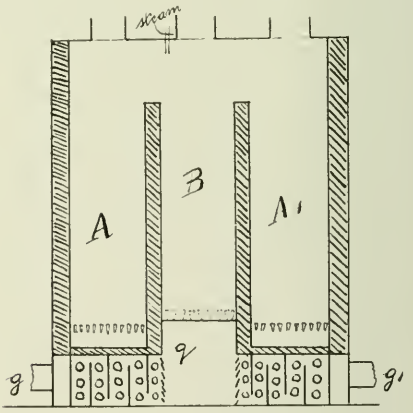


FIG. 5.—MODIFICATION OF FIG. 4.

cbm weighs, therefore, 1.1 kilo, and we get from the total of 260 kilo gas, 260 : 1.1 = 236 cbm gas or 8.100 cu. ft. gas.

Besides the gas there is tar generated, generally between 4 to 6 per cent of the weight of the air-dried peat. This tar I will not put into the figuring, but include it in the 26 per cent gases, thus taking a more unfavorable standpoint than is offered by the actual conditions.

In this new form of coking we can coke in chamber *B* from 2 to 3 tons of peat on 1 ton burned up in chamber *A* and we, therefore, get, besides the gas obtained in *A*, an additional gas of 8.100 × 2 = 16.200 cu. ft. But this gas, as is generated in chamber *B*, is much higher in heating value than this of chamber *A*. It has 320 to 350 b.t.u. per cubic foot, and so we obtain:

Chamber *A* 87,500 cu. ft. gas, each 135 b.t.u., or 11,812,500 b.t.u.; chamber *B*, 16,200 cu. ft. gas, each 320 b.t.u., or 5,184,000 b.t.u. Total, 103,700 cu. ft. = 16,696,500 b.t.u.

This gives 1418 hp; 1 ton of peat burned in chamber *A* costs $1; the gas and tar from chamber *B* is 25 per cent of the applied peat, which costs $2. The total cost of the 1418 hp, as to fuel-cost, amounts to $1.50, or 1 hp-hour at 0.107 cent.

It is evident that the addition of the coke gases to the producer gases is quite a valuable one. I outlined this process for peat because my practical experiences refer me to this material, but the conditions in regard to lignite are so closely

related to those of peat that there will hardly be any change but that given by the different composition of the new material.

The work with lignite is in many regards much better than with peat, as lignite has about 10 per cent more fixed carbon; its content of water is more uniform, and so the relation between the generated steam and the resulting coke is much more favorable to the work with lignite than with peat; with the latter material this point must be carefully studied.

The heating value of the peat gas referred to in my calculations is pretty low, but it is to be considered that it is obtained with a peat varying from 30 to 40 per cent of water. A good producer will, with peat of 25 to 30 per cent water, always furnish a gas of an average heating value of about 150 b.t.u. per cubic foot, and the United States Fuel Testing Plant obtained in one case, with peat from Orlando, Fla., a gas of 170 b.t.u. If we take the additional heating value of the coke gases we will arrive at an average heating value from about 180 to 200 b.t.u. per cubic foot, a figure which never was, and never will be, obtained with anthracite or coke in an average gas producer.

To sum up, we may say that according to European practice (supported in the most successful way by the exhaustive experiments of the United States Fuel Testing Plants at St. Louis and Pittsburgh) the low-grade fuel is very well suitable to furnish an efficient gas for power purposes and to furnish fuel in the form of coke as is equal to the good average coal.

Furthermore, the already extremely low price of 0.115 cents for 1 hp-hour as to fuel cost will be still more favorably modified by the addition of the coking gases; the resulting coke, which will be from 30 to 40 per cent of the peat supplied to chamber *B*, will make up for the by-products as obtained in other processes and is certainly a more desirable by-product as there is always a market for fuel, but not for cheap and bad tar. The project does generally not pay much attention to the recovery of ammonia, but in case chamber *A* is run exclusively on conditions of the gas producer, the temperature in chamber *A* admits of the existence of ammonia and so there will be a way for larger units to consider this point.

The point as outlined here was especially designed for power plants below 1000 hp so as to make the operator (generally an engineer not very familiar with chemical problems) entirely independent of matters which cannot be but troublesome to him.

We are obliged to the United States Geological Survey for a very conservative estimate of the peat supply in the United States, and the highest credit must be given to Prof. Chas. A. Davis, expert in charge of the Peat Division, Geological Survey, Washington, D. C., for giving us reliable figures in regard to that point. All the peat in the United States suitable for coking has a value of 37 billion dollars, and there is still a great amount of stuff which would not do for coking, but would be excellent for gas. As one acre of peat land supplies about 200 tons air-dried peat per foot of depth and a peat bog of some extension furnishes material of low and high ash content a furnace as I outlined will be of great benefit, as with the material high in ash one produces gas in *A* and with that low in ash one produces coke in *B*.

Inoxidation Processes for Protection of Iron and Steel.

BY ALFRED SANG.

History.—Mill scale, which is mostly composed of black magnetic oxide of iron, forms a non-continuous coating and is a promoter of corrosion. Lavoisier, during his memorable investigation of the composition of water in 1781, discovered the artificial formation of the black oxide (Fe_3O_4) on iron as a continuous impermeable skin and noted its stable properties. Professor Faraday, in 1858, reported on the protective properties of the magnetic oxide formed by the action of the steam in the superheating tubes of H. M. L. "Bustler." Berthier discovered its formation when iron is subjected to the action of highly heated air. Finally, Prof. Frederick S. Barff, of London, being engaged in charring peat, noticed the highly preservative action of this coating, which had formed on the inside of a pipe conveying superheated steam.

Barff Process.—The Barff Process was first made known in a paper read before the Society of Arts in 1876, and another before the Iron and Steel Institute in 1877;[1] it has also been thoroughly treated by B. H. Thwaite.[2] In this process the articles are heated to about 1000° C. (1832° Fahr.) and steam superheated to 1000° Fahr. (538° C.) is injected into the coating chamber.

Bower Process.—Mr. George Bower, of St. Neots (Huntingdonshire) interested himself in this process and tried using air instead of steam; he was not successful, however, until his eldest son, A. S. Bower, conceived the idea of using a producer gas, rich in carbonic oxide, to reduce the red oxide, as obtained by air treatment, either by Barffing or by subjecting the work to acid fumes. A type of furnace well adapted for the purpose was designed, in which the air treatment lasted 40 minutes and the gas treatment 20 minutes, these being repeated alternately four to eight times. Finally the Barff patents were purchased in order to secure a satisfactory first coating of red oxide in a practical manner. The costly experiments undertaken by the Bowers had consumed close on three years.

Bower-Barffing.—The process known as Bower-Barffing consisted in heating the articles to be coated in a closed retort to a temperature of 1600° Fahr (871° C.), superheated steam was then interjected, forming a coating of both the black triferric tetroxide (Fe_3O_4) and the red ferric oxide (Fe_2O_3); this first operation lasted 20 minutes and was followed by the injection during 15 to 25 minutes of carbonic oxide (CO) from a gas producer, which reduced the Fe_2O_3 to Fe_3O_4. These operations could be repeated alternately any number of times until a sufficient depth of oxidation had been obtained. A Bower furnace 12 ft. to 14 ft. long, 4½ ft. wide and 4 ft. deep would treat one to two tons in 24 hours. Three attendants were required night and day for two furnaces.

The Bower-Barffing process was brought to America by Mr. A. S. Bower and introduced to the engineering world in papers read before the American Institue of Mining Engineers[3] and the American Society of Mechanical Engineers.[4] The Hecla Iron Works, of Brooklyn, N. Y., were the first to use it. During his stay in America Mr. Bower was successful in his experiments of using superheated steam during the last one to two hours, and found that the best results were obtained when the steam was at a higher temperature than the articles undergoing treatment.

The process is an expensive one, the cost being said to range from $5 to $20 per ton, and probably more in many cases. The articles come out with a dark-gray appearance, which changes to black on being oiled, and they are somewhat increased in size. Any sand left in castings leaves red traces resembling rust. The surface can be polished or can be given a very fine appearance by brushing with emery and oil, then dipping in a strong solution of potash, and finally cleaning with sawdust, especially if the articles have been polished before treatment.

Enamel will hold on very tenaciously and paint can be applied without trouble. Other points worth noticing are that close packing in the furnace does not prevent action at the points of contact, and the process being one of annealing, the influence on the physical condition of the iron and steel is to be considered before treatment. The coating if too thin will chip off. It is said to be a perfect protection against sea water, and on account of its close adherence when any part of it is broken off the iron only rusts at the point exposed.[5]

[1] *Journal Iron and Steel Institute*, 1877, p. 356.
[2] "On the preservation of iron by its own oxides." *Proc. Inst. Civil Eng.*, Vol. 74 (1883), p. 255.
[3] A. S. Bower, *Transact. Am. Inst. Min. Eng.*, Vol 11 (1882), p. 329.
[4] Geo. W. Maynard, *Transact. Soc. Mech. Eng.*, Vol. 4, p. 351.
[5] "The preservation and ornamentation of iron and steel surfaces," by Geo. Bower before the Soc'y of Engineers, May 7, 1883. *Transact.*, Vol. 43, p. 59.

The coating resists acid fumes better than does galvanizing, and it is not affected by sulphate of copper. The difference between the coefficient of expansion of the iron and the oxide being only slight, the work will stand almost any degree of heat without injury, but it can neither be bent nor machined and the temper and edges of tools would be destroyed if treated. Wrought iron requires less heat than cast iron. If part of the coating is removed, the exposed parts rust more readily than ordinary iron. The articles treated are weakened, not only to the extent of the iron which has been converted into oxide, but also by the burning out of the cinder in wrought iron, causing what is known as "dryness."

It has been found excellent for pipes used in mines and for conveying mine water, which is high in sulphur and acids; it has also been recommended for boiler tubes, but does not seem to have been adopted for that purpose. The "noble" metals can be deposited from their chlorides on the oxide coating by the Dodé process. An improvement introduced later into American practice, known as the "Wells process," consists in finishing the work at one operation by using steam and carbonic oxide together, instead of applying them alternately. The Bower-Barffing process and the one which follows have been excellently described and discussed by Mr. M. P. Wood.[4]

Gesner Process.—Another process not unlike Bower-Barffing was introduced on a commercial scale some years later by the late Dr. George W. Gesner, of Brooklyn;[5] it is known as the Gesner process. The deposit in this case is said to be a compound of hydrogen, iron and carbon, or as the inventor claimed, a superoxide, plumbago and hydron, the latter being a hydrogen-iron alloy; analysis shows that there is not less than 2 per cent of hydrogen present.

The mode of operation is as follows: The coating retort is kept at a temperature of from 1000° Fahr. to 1200° Fahr. (538° C. to 649° C.) for a period of 20 minutes, after which steam at a low pressure is allowed to act at intervals during 35 minutes; this steam is brought into the retort through a red-hot pipe at the bottom, known as the hydrogen generator; this would imply that the steam is entirely decomposed, but this can hardly be correct as the decomposition of steam commences at 1000° C. to 1200° C. (1832° Fahr. to 2192° Fahr.) and is completed at 3000° C. (5432° Fahr.) only. The last step of the process is to slowly pour in a small quantity of naphtha or other hydrocarbon and allow it to act during 15 minutes; it reduces any red oxide present and carbonates the surface. Finally the heat of the retort is reduced to 800° Fahr (427° C.) and the articles are withdrawn.

Roofing sheets, steam radiators, architectural iron work, tubes and smaller goods were successfully treated by this method. The charge for coating small articles ranged from 4½ cents to 7 cents per pound, and for large pieces in quantities as low as 1 cent per pound. The advantages claimed over Bower-Barffing are that on account of the low heat, articles are not increased in size or bent out of shape, and that there is no need of removing grease or oil before treatment. Articles treated by the Gesner process will take paint, and tables have been published showing that there is no appreciable loss of strength and no reduction of elongation in steel, although there is some in iron. The essential requisite of duplicating results was very difficult at first and large sums were expended in experimental work. There is a plant in operation at South Brooklyn

In 1897 Dr. Gesner patented[6] the alloy of hydrogen and iron which he described as resisting oxidation and corrosion, being capable of working like iron and being of nearly the same strength, but of somewhat lower specific gravity. The mode of production was to blow hydrogen through iron in a converter, 1000 cu. ft. of hydrogen at 60° was sufficient for 2000 lb. of iron or steel; the temperature of the metal was to be 2800° Fahr., and the depth 15 in.

In 1900 he took out a further patent[7] on the alloy which is formed as a scale by the action of hydrogen on hot iron; the hydrogen was to be produced by the decomposition of steam (producer gas) and the scale was to be crushed, ground and sieved for purposes not specified.

Other Processes.—The process patented by W. Dewees Wood,[10] of McKeesport, Pa., wherein sheet iron was subjected to the action of hydro-carbon vapors or gas and superheated steam within an air-tight and heated chamber, is identical in principle with the Gesner process, which it preceded. Planished iron, as commercially supplied, has a grayish oxidized surface; it is a sort of Russia iron.

There is an old process for oxidizing iron and steel by means of melted saltpeter or niter (nitrate of potassium, (KNO_3), which was greatly improved by Col. A. R. Buffington,[11] of Watervliet Arsenal, in 1884, and may be considered superior to Bower-Barffing wherever high heat would destroy some necessary quality of the articles.

The process may be briefly described as follows: Saltpeter (KNO_3) and black oxide of manganese (manganese dioxide, MnO_2) are heated together in an iron pot; the saltpeter will fuse, and when the heat is such that sawdust thrown on the surface of the dip will ignite, the pieces to be oxidized are put in cold and stirred about, then suspended for five minutes in the fumes over the pot and finally dipped in boiling water to cool and to clean off any saltpeter which may adhere to their surface. The saltpeter must be of good quality or the results will be unsatisfactory. Cast iron takes on a fine bronze color. The oxidization is evidently due to the action of nascent oxygen.

Claudius has proposed[12] a 5 to 6 per cent solution of manganese nitrate for the production of a durable black coating or patina. The articles are dipped and then dried slowly over a fire or gas flame, the non-adherent powder is brushed off and the operation repeated as often as necessary, then rubbed with oil.

It has also been proposed to protect metal articles with a film of sulphide by subjecting them, in a heated state and in the absence of air, to the action of the vapors of sulphur.[13] In the same way a coating of phosphide has been produced by subjecting iron plates to the action of phosphorus at a high temperature.[14] Russia iron, which was long made under a secret process by Russian manufacturers, is a steel having its surface cemented and oxidized by heating it in piles, with carbon in between the sheets; the fact that this coating was mostly Fe_3O_4 was not known until pointed out by Dr. Percy. Many variations of this process have been patented.

A slight flexible coating of black oxide has been given to wire, which was first rusted by means of steam (the rust given by acid fumes being too loose) by heating in a special furnace and dipping in oil.[15] Iron cleaned with nitric acid, then heated and finally dipped in castor or other oil till cold will turn black.[16]

Hydræfer Process.—Mr. J. J. Bradley, of Brooklyn, who was for years connected with the Gesner process, has developed and operated a somewhat similar process, for which certain advantages are claimed. It requires but one furnace operation, which lasts one hour or less, and the color of the product is a blue-black, equal to the finest Bower-Barffing, and can be brought out by rubbing with whale or other oil. The process, which is patented, owes its name to the use of brass in connection with the partly decomposed steam which is injected into the retort. The metal to be coated is kept at a temperature of about 1100° Fahr. (593° C.).

[4] "Rustless coatings for iron and steel." *Transact. Am. Soc'y Mech. Eng.*, Vol. 15 (1894), p. 998; Vol. 16 (1895), pp. 350 and 663; Vol. 18 (1897), p. 252.
[5] See *Scient. Am. Suppl.*, Vol. 26 (1888), p. 10,442; also *Jour. Iron and Steel Inst.*, 1890 (2), p. 850; also *Iron Age*, Vol. 45 (1890), p. 544.
[6] Engl. Pat. No. 9,103 of 1897.
[7] Engl. Pat. No. 11,166 of 1900.
[10] U. S. Patent No. 252,166 of 1882.
[11] *Transact. Am. Soc. Mech. Eng.*, Vol. 6, p. 628.
[12] *Metallarbeiter*, Vol. 24, p. 318.
[13] P. H. Conradson, U. S. Pat. No. 311,294 of 1885.
[14] Eng. Pat. 695 of 1864.
[15] Chas. Platt, *Engineering and Mining Jl.*, 1892 (2), p. 78.
[16] Eng. Pat. No. 16,451 of 1888.

Electric Process.—Iron and steel surfaces have also been oxidized by electrolysis, the first one to attempt it being A. de Meritens.[17]

The bath was one of distilled water at a temperature of from 70° C. to 80° C. (158° Fahr. to 176° Fahr.) and the cathode was made of copper, carbon or iron indifferently, or could be the tank itself; the work, which was preferably polished, was connected as anode; as weak a current as the water would conduct was then applied for two hours or more and the nascent oxygen given off in the presence of the dissociated hydrogen occluded in the metal, produced a film of black magnetic oxide, increasing in depth with the length of treatment.

If the current was too strong, pulverulent rust would be formed, but with the lower-current rust itself would be converted into the black oxide. No permanent deep coating could be formed unless there was hydrogen present in the iron and on this account it was often necessary to first run the article to be treated as the cathode in order that it might absorb hydrogen. This process is evidently the electrical equivalent of the various inoxidation processes already described; all heat processes seem to have their electrical equivalents; it is a natural consequence of the electrical nature of chemical action.

PITTSBURGH, PA.

The Permanent Mold and its Effect on Cast-Iron.*

BY E. A. CUSTER.

In looking over the work done by this and kindred scientific societies, one cannot fail to be impressed with the wonderful advance that has been made in the knowledge their close scientific research has given us, as well as with the logical means they have pointed out in order that this knowledge may bear practical fruit. Day by day the patient, painstaking work is carried on and unselfishly given to the world at large.

FIG. 1.—CASTINGS WITH SMALL EXCRESCENCES.

It is perhaps natural that the major part of these researches are directed toward steel. The ramifications of this metal are hourly extending, and it is small wonder, in view of what has been accomplished, that the attention of scientific thinkers and investigators has been largely turned to its study. It is at this stage the writer comes forward with a plea for the humble cast iron.

The work noted in this paper covers a limited field, but enough has been learned to give rise to the thought that in this crude material there lurk potentialities which when scientifically investigated may not only enlarge this field, but put an entirely different phase on our understanding of cast iron.

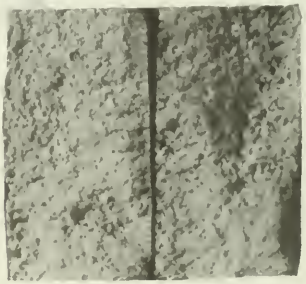
Some four years ago, under the stimulus of a disastrous strike, we started on the hunt for the permanent mold, and finally selected cast iron as the material offering the greater number of advantages and the least number of objections. In the course of our investigations it was noticed that certain of the castings when cool were soft, while others were hard—in fact, chilled white—the hard castings being in an overwhelming majority.

FIG. 2.—FRACTURES OF PARTIALLY CHILLED CAST IRON.

As a remedy we tried various mold coatings of inert materials, but we found that while certain of these coatings gave very good results when applied thickly, yet they slowed up the process. In an effort to gain time the coating was neglected, and it was ascertained that when working at good speed, the major portion of the castings were soft and could be easily machined.

When the coating was entirely discarded and the castings poured and removed from the mold as soon as they had solidified sufficiently to handle, the total production was soft and no hard castings were produced. After some 14,000 or 15,000 castings had been made under every condition that could be obtained in an ordinary foundry, the following bases were established:

(1) Molten cast iron does not chill (using the word "chill" to express hard, white crystals) until after it has solidified.



FIGS. 3 AND 4.—FRACTURES OF CAST IRON. (A) SOFT, (B) HARD

(2) Chilling molten iron swiftly to the point of solidification, and then allowing it to cool normally, produces a homogeneous metal.

(3) This homogenous metal possesses certain characteristics that are entirely absent when the same molten iron is poured in sand and allowed to cool in the mold.

(4) The chemical constituents of the iron, with the exception of carbon, have little or no effect in modifying these characteristics when gray iron, within ordinary limits, is used.

[17] *Bull. de la Soc. Int. des Elec.*, Vol. 3 (1886), No. 29, p. 230.

*A paper read on June 30 before the American Society for Testing Materials. Mr. Custer is the president of the Tacony Iron Company, Philadelphia.

Inasmuch as all work we have done has been in sections ranging from 1/2 in. to 1/8 in., it is obvious that the results obtained must be considered in direct comparison with those obtained when these same sections are cast in sand. The casting of low in silicon that it will form white crystals when made in sand will inevitably form the same white crystals if cast in a permanent mold, even though treated by the process outlined above. This applies principally to thin sections; how far this

FIG. 5.—CASTING.

process can affect thick sections depends entirely upon the ability of the investigator to rob the molten mass of its heat.

In support of the first two propositions it may be said that molten cast iron is a solution of carbon in iron, with the addition of silicon, phosphorus, sulphur, manganese and certain impurities—all forming a homogeneous fluid mass. Now, if this mass can be instantly cooled it will still be homogeneous,* the different elements not having time to segregate. Instant cooling is clearly impossible, but we find that swiftly chilling the molten mass produces practically the result desired. The molecular action of forming white, hard crystals is only started.

When the casting is removed at a bright, yellow heat, with the

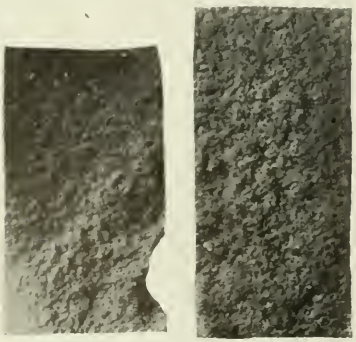


FIG. 6.—FRACTURE OF HIGH-SILICON, LOW-SULPHUR CAST IRON, HARD (LEFT). FIG. 7.—FRACTURE OF LOW-SILICON, HIGH-PHOSPHORUS CAST IRON, HARD (RIGHT).

interior still molten, this molecular action—which is nothing more nor less than a continued closing together of the particles—compresses the molten iron to such an extent that globules of iron exude through the pores and form small excrescences on the surface. This is further shown by the fact that when iron is cast in long bars these bars do not pipe, but the molten iron moves toward the top of the bar, which is partially molten, and forms excrescences at the top. This is exemplified in Fig. 1.

Since the cooling medium, i.e., the iron mold, is removed at the point of solidification, there is no further tendency toward forming larger crystals; furthermore, segregation is completely prevented by reason of the rapidity with which this chilling action is performed. We have tried to reproduce this effect in sand molds, but with no success.

Fig. 2 shows a broken section of a casting one side of which was retained in the mold long enough to produce the white crystals; the other side is soft gray iron. This clearly proves the first proposition.

Fig. 3 is a section from another casting, which was taken from the mold when the point of solidification was reached and was allowed to cool normally.

Fig. 4 shows a section of the same casting taken from the mold at a bright red and quenched in water.

Nos. 2, 3 and 4 were poured from the same ladle of iron. The analysis of this iron is: 2.12 Si, 0.098 S, 0.70 P, 0.38 Mn, 3.49 T.C.

No. 2 is useless as a casting, showing white crystals on one side and dark gray on the other.

No. 3 is clean, soft, easily machined and is as nearly homogeneous as can be shown by any test we can devise. It has a dark gray fracture, machines cleanly, the chips being free from fine dust, and does not show the usual hard scale on the exterior. When heated to a bright red or yellow heat and

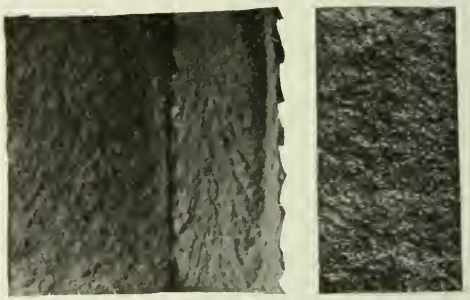


FIG. 8.—FRACTURE OF FILE AND HARDENED CAST IRON (LEFT). FIG. 9.—FRACTURE OF ORDINARY CAST IRON (RIGHT).

quenched in cold water it has a very light-gray fracture and is as hard as tempered tool steel. When used as a cutting tool it will outlast any ordinary high-carbon steel. Bring it in contact with a working dynamo after hardening, it becomes a permanent magnet.

It does not possess the disadvantage of increasing in bulk when repeatedly heated and cooled. This is illustrated by Fig. 5—a casting that has a distortion of but 0.002 of an inch after being brought to a bright red heat and quenched in cold water, the operation being repeated 10 times. Once having imparted to the iron the properties enumerated above, it is impossible to remove them except by remelting. If No. 3 be held in a bright flame until metal drips from the end, the remaining iron will be unchanged in every particular, with the exception of a slight coating of oxide.

Fig. 4 shows a light-gray fracture, and is an exact duplicate of No. 3 hardened. When heated to the temperature at which it was hardened and allowed to cool normally, it reverts to the characteristics of No. 3. This heat need not be long continued; the mere heating to the proper temperature is sufficient to accomplish the result.

Figs. 6 and 7 are from the same mold. The analyses: No. 6: 2.94 Si, 0.032 S, 0.028 P, 0.38 Mn, 3.08 T.C.; No. 7: 1.75 Si, 0.07 S, 1.42 P, 0.41 Mn, 3.22 T.C.

These present precisely the same phenomena as Nos. 3 and 4, so far as any tests applied will show.

It would seem, from the analyses of the treated samples, that the peculiar properties observed are entirely independent of whether the silicon, sulphur or phosphorus is high or low, at least within the limits noted. It is immaterial whether the silicon is 1.75 or 3 per cent, the sulphur 0.02 or 0.12 per cent, or the phosphorus 1.50 or 0.03 per cent; in any event the same practical result is obtained if the procedure outlined is correctly carried out. In no respect have we been able to duplicate these results when the same iron was poured into sand molds of like dimensions.

The logical explanation of this hardening property is that the molecular action which produces a homogeneous metal by chilling molten iron to the point of solidification, is again the medium of producing the extreme hardness. The first chilling brings the molecules to what might be termed a receptive position. Removing the chilling medium holds this position, and as the temperature falls the molecular position becomes permanent.

If at the receptive point the casting be quenched in cold water, the great unmeasurable force of heat expansion and contraction is brought into play. No one knows how many tons per square inch is exerted when molten iron cools. This force is always greater than the tensile strength of the material under treatment. If, now, the semi-solid iron be subjected to this presumably enormous force exerted through the mold, swiftly robbing it of its heat, it probably follows that the molecules are crushed together with an enormous pressure, and an extremely dense structure results. If the casting be quenched in oil, there is no hardening effect; it remains soft. If thrown into boiling water it cracks into pieces.

Fig. 8 is the fracture of an ordinary forged and hardened steel file placed alongside of hardened cast iron, in this case Fig. 4. The analyses:

File .. ..0.19 Si, 0.022 S. 0.019 P, 0.25 Mn, 1.28 T. C.
Cast iron ....2.12 Si, 0.098 S. 0.70 P, 0.38 Mn, 3.49 T. C.

This photograph shows very clearly the coarse grain of the cast iron and the metal flow of the steel file, yet the cast iron is the harder metal.

Fig. 9 gives a very good idea of the difference between casting in sand and in a permanent mold. This fracture is of the same iron that was used for 2, 3, and 4, and was cast in a green-sand mold and allowed to cool normally. Figs. 10, 13 and 20 are microphotographs of Figs. 3, 4 and 9, and present a very fair field for discussion. They were etched with picric acid and each given a magnification of 104 diameters. The fracture photographs are given a magnification of 2½ diameters.

In this work carbon plays a large part, although it does not seem to have the same effect as when iron is cast in sand. A few notes on this phase may be interesting.

Since all the carbon in molten iron is in solution, and exists in the combined form, then, if molten iron be instantly cooled to 1000 deg. Fahr., all the carbon will be held in the combined form—there will be no free carbon. If, however, it be instantly cooled to the point at which the iron sets, and then allowed to cool normally, the carbon will be in the combined form at the time of setting, but will change to the free form as the cooling progresses. This formation of free carbon is very rapid; the major portion present in the casting is formed within a few seconds after it is taken from the mold. The analyses below give a very fair idea of this action, the pieces in question being 6 in. x 1¼ in. x ½ in.:

	C. C	F. C	Si.
Cast in sand and cooled normally.. ...	.21	2.93	2.61
Taken from permanent mold at bright yellow and quenched	1.50	1.52	2.61
Taken from permanent mold at bright red and quenched	.49	2.61	2.61

It will be seen from this that two-thirds of the combined carbon has been changed in the few seconds required to cool from a bright yellow to the bright red. The free carbon in all these castings is not in the form of graphitic carbon, as we usually see it in ordinary cast iron, but partakes more of the character of annealing carbon, as exhibited in a malleable casting.

Here we have an iron containing 2.61 silicon and 2.50 free carbon that possesses the property of taking a temper equal to tool steel, and this without the least indication of what is generally termed "chill."

Fig. 10x104. Fig. 11x30. Fig. 12x30. (Oblique light)

FIGS. 10 TO 12.—IRON CAST IN PERMANENT MOLD. (SOFT, SAME AS FIG. 3.)

At this writing, the tensile strength is under investigation. The scope of this research is very large, and many elements must be taken into consideration. Our results so far indicate that cast iron, when chilled in a permanent mold to the point of setting and then cooled normally, is greatly increased in tensile strength, and that this strength does not materially vary within the chemical range of ordinary foundry iron.

The thickness of the section and the initial heat of the casting have the most influence in determining the ultimate strength, and these variations call for an extended consideration.

Heretofore cast iron has had a rather poor reputation, being generally unstable and yielding reluctantly to any treatment that would tend to improve the quality. The permanent mold has done valuable service in demonstrating that the simplest of simple heat treatments endows it with characteristics that entitle it to a very large portion of the consideration that has hitherto been enjoyed by wrought iron and steel. One hardly dare say that the ultimate possibilities of this metal have been reached, nor can it be considered in the light of an unstable and retractory medium. On the contrary, it answers readily and surely to the proper treatment. The field is wide, and gives promise of much that would place cast iron on a far higher plane than it occupies to-day.

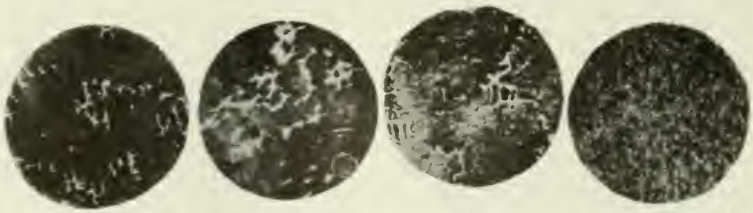


Fig. 13x104. Fig. 14x104. Fig. 15x104. Fig. 16x30. (Oblique light)

FIGS. 13 TO 16.—IRON CAST IN PERMANENT MOLD. (HARD, SAME AS FIG. 4.)

I wish to acknowledge the keen interest and self-sacrificing help of Mr. Robert A. Pitman, without whose devoted work much of what has been accomplished would have been lost.

The Generation of Producer Gas.

By Oskar Nagel, Ph.D.

The producer is a simple and efficient apparatus for the manufacture of a cheap industrial gas. Other important advantages of this process are: smokeless combustion of great uniformity, exact regulability of the fire and heat, and the attainment of very high temperatures by preheating the air of gasification and combustion. By working with an excess of air or gas, respectively, an oxidizing or reducing flame is produced. Finally the combination of the various fireplaces into one central station and the saving effected in the cost of transportation of fuel and ashes are factors which should by no means be underestimated.

Our solid fuels contain besides the free carbon also carbon which is combined with hydrogen and oxygen. These compounds form the bituminous or volatile components of the fuels. They amount in wood up to 82 per cent of the total combustible matter; in peat to 60 to 65 per cent; in lignite to 55 per cent; in bituminous coal to 45 per cent or less, and in anthracite to 5 per cent or less.

Fig. 17 x 104.—Iron cast in permanent mold. (Hard, same as fig. 6.)

If fuel is heated under exclusion of air, the volatile matters are separated, i.e., the coal is being "degasified." In this process hydrocarbons, hydrogen and also carbon monoxide, carbon dioxide and water are formed. The latter increases with the moisture content of the fuel and escapes during the destructive distillation (degasification). The residue—pure carbon and ash—is called coke, charcoal or peat coal.

If the destructive distillation is carried on at high temperature, as, for instance, in gas works and coking plants, a strongly illuminating gas and liquid tar are formed. At low temperatures the quantity of hydrocarbons is larger, the illuminating gas and hydrogen decrease considerably, the tar gets thick, and, with lignite and peat, also paraffine is produced. The destructive distillation at low temperature also occurs—to the disgust of the manufacturers—in the generation of producer gas.

The generation of producer gas is based upon "gasification," i.e., the transformation of the free carbon of the fuel into carbon monoxide, and it is easily understood that for this process a fuel containing the largest amount of carbon and the smallest amount of volatile matters will be most desirable. Such fuels as anthracite, charcoal and coke, however, though easily transformed into a gas free of tar, are too expensive to be used in the big industries, which are forced to use bituminous coal, wood and lignite.

Fig. 18x104. Fig. 19x104. Fig. 20x104.

Fig. 18 to 20.—Iron cast in permanent mold. (Hard, same as fig. 7.)

In small producer plants, especially in connection with gas-power plants, the higher price of anthracite is outweighed by its greater convenience. But even here conditions are changing and the use of bituminous fuels is being slowly but surely introduced.

The gasification of the carbon in the producer is effected in such a manner that the carbon is first burned to carbon dioxide, the latter being then reduced to carbon monoxide by contact with additional carbon. Hence, carbon monoxide is the essential principal of producer gas.

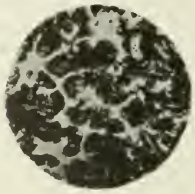


Fig. 21 x 104.—Same iron as no. 3, but cast in sand. See fig. 9.

Fig. 22 x 104.—Fragment from large casting.

The perfect reduction of dioxide to monoxide takes place, theoretically, at a minimum temperature of 1000° C., which is easily produced by combustion to carbon dioxide. At lower temperatures part of the dioxide is not reduced, the formation of the monoxide stopping entirely at about 450° C.

In order to effect the reduction, a high fuel bed is used and less air admitted than would be necessary for complete combustion. The formation of carbon monoxide caused by too high a layer of fuel is of frequent occurrence in ordinary fireplaces and means a considerable loss. It is also known that in direct firing a considerable excess of air has to be admitted if the formation of carbon monoxide is to be avoided.

The height of the fuel bed in producers necessary for complete reduction varies with the quality of the fuels used. Dusty fuels require less height than coarse, loose, fuels. The proper height for 1-in. coke is 30 in.; for 1½-in. coke, 45 in.; for 2¼-in. coke, 72 in.; for ¾-in. bituminous coal, 22 in. are sufficient; for run of mine, 60 in. to 80 in.

This fact shows that it is of advantage to use fuel of uniform size in the producer. Coarse pieces of dust interfere with the uniformity of the gas production and allow the formation of holes, i.e., vertical channels in the fuel bed, so that a part of the air admitted to the producer goes through unchanged, simply deterioriating the gas. However, the low price of run-of-mine coal necessitates its application in industrial gas producers whereby the prevention of hole-formation by means of poking becomes imperative.

With bituminous fuels too high a fuel layer is not to be used, as this causes an increased formation of tar and soot, for the volatile matters and the moisture escape from the higher zones before the fuel reaches the incandescent zone of reduction. The higher the temperature of the upper layers, the thinner will be the tar produced and the more hydrogen and methane will be found in the gas. The two latter components increase the thermal efficiency, but the former, together with the soot, are disagreeable impurities of the gas, more so if the gas is cooled before its use.

This is always the case where the producers are not built right at the furnaces in which the gas is to be burned. On the other hand the separation of the tar, which has a certain thermal efficiency, and the cooling of the gas involve always a loss. Experiments have lately been made to utilize the tarry components of the producer gas or to decrease the quantity of tar formed. It is known that tar, if drawn through incandescent coal, is transformed into permanent gases (hydrogen, methane, etc.).

As stated above, a temperature of not less than 1000 deg. C. is required for complete formation of carbon monoxide. If considerably higher temperatures are applied, the disadvantages will be found to outweigh the advantages, as by such high

temperatures the fire-brick lining is rapidly destroyed and the ashes of the fuel always obtained as molten slag.

Such slag formations occur with various grades of fuels, depending upon the composition of the ash, at higher or lower temperatures. In the latter case it can only be avoided at the expense of the gas production. Here the addition of water to the gasifying air is a simple remedy, which, at the same time, increases the thermal value of the gas and the efficiency of the producer, simultaneously cooling the grades of the producer.

Incandescent coal decomposes water into its elements. The hydrogen formed enriches the gas and the oxygen combines with the carbon to carbon dioxide or monoxide according to the prevailing temperature. The formation of monoxide by the decomposition of water is most complete at a temperature of 1000 deg. C., while at lower temperatures more and more carbon dioxide is produced. In practice, however, it is impossible to decompose all the water contained in the gasifying air. One part goes always unchanged through the producer and increases the moisture content of the gas. If this moisture is present in the gas during its combustion it has a heat-consuming effect and decreases the temperature of combustion.

Hence, no water is to be added for the gasification of fuels rich in water, and some fuels require even drying, if with the gas produced a somewhat high temperature is to be reached. It is also evident that the temperature of the gas leaving the producer decreases with the temperature of the producer and with the increasing amount of heat which is disposible for degasification and evaporation.

If, for instance, in the gasification of dry bituminous coal the temperature of the gas leaving the producer is 600 deg. C. to 800 deg. C., a temperature of only 400 deg. C. to 500 deg. C. will be observed if water is added. This shows that by addition of water less heat is lost by the cooling of the gases, the loss by radiation being also simultaneously decreased.

Of great importance is the question: How much water may be advantageously added? Fuels with a large percentage of volatile matters can stand only a small addition of water, as, already during their degasification, much water is formed; i.e., much heat is lost. If such fuel is also very moist, the result may be a non-combustible fuel gas, if the gas is not dried before being used by cooling, whereby a large part of the water may be removed by condensation.

The amount of water added must be regulated so that the walls of the producer do not suffer by the heat and that, as much as possible, the formation of liquid slag is avoided.

In gasifying pure carbon 1 kg of water may be added to 4.5 cbm of cold gasifying air without causing any loss of heat and as for gasifying 1 kg of carbon about 4.5 cbm of air are required, the upper limit of the addition of water is about 1 kg to 1 kg of carbon.

If the air of combustion and the water added are preheated the quantity of the latter may be increased and may reach at 550 deg. C. double the amount mentioned above. This explains why in practical gasification of coke, which is practically pure carbon, 300 to 400 grams of water are added per cubic meter of air if a gas rich in hydrogen is to be produced.

In gasifying bituminous coal for the production of a gas not too rich in hydrogen, 150 to 200 grams of water are taken per cubic meter of air. From a theoretical point of view, however, a somewhat larger addition of water is nearly harmless, so far as the utilization of the fuel is concerned. It is true that in such a case a larger quantity of carbon dioxide will remain unreduced, but with the increased quantity of decomposed water, also more pure oxygen will get into the producer. Hence, less gasifying air is required, which means a decrease of the nitrogen content of the gas produced.

The composition of producer gas is varying a great deal. Under normal conditions, if a good grade of fuel is used and the operation properly carried out, the gas will contain about 25 per cent of carbon monoxide. If the producer gets very hot, caused by the total or nearly total absence of water, the content on carbon monoxide may be up to 30-31 per cent.

The second combustible component of producer gas is hydrogen, varying in quantity between 8 to 14 per cent. However, the hydrogen content may be even higher or lower, depending upon the moisture of the gasifying air and other conditions. Some factory managers are afraid of too high a content on hydrogen and believe that it does harm to the firebrick and affects the finished product disadvantageously.

So, however, continued operations with producer gas from peat, which is rich in hydrogen, have been and are being carried out successfully; the harm—if any—done must be due to some other cause, probably to the moisture of the gas, which causes decomposition of and recomposition to water, thereby effecting numerous disagreeable complications. Accordingly a gas rich in hydrogen would have to behave differently when cooled (dried) before its use or when used hot.

That the hydrogen cannot be the only cause of the above-mentioned complications (sudden rise of temperature) is shown by the fact that carbon monoxide in combustion, though not yielding as many thermal units as hydrogen, produces a higher temperature. Hence, a gas, which on account of its high content on hydrogen, has a higher thermal value as compared with others, may be equivalent to the latter, as far as the temperature of combustion is concerned.

There is a certain relation between the percentage of carbon dioxide and the percentage of carbon monoxide and hydrogen. That it is not always of advantage to get a gas with the lowest possible content of carbon dioxide we can see from the fact that at dry gasification, where very little dioxide is formed, the efficiency of the producer is much lower, as with a large addition of water.

On the other hand, the content on dioxide is also influenced by the nature of the fuel, as with low melting slag the temperature must be kept so low that the complete transformation of dioxide into monoxide is prevented. Some grades of coal, therefore, will only difficultly be gasified at reasonable economy if the formation of slag is not taken into consideration and if the producers are not constructed to suit these conditions. As a rule the carbon dioxide should not go above 3 or 4 per cent.

The methane gets into the producer gas from the products of decomposition of the volatile matters. The quantity of methane varies from 1 to 3 per cent and depends upon the temperature of degasification. The heavier hydrocarbons are also sometimes found in traces if the temperature of degasification is very high.

If the tarry compounds of the gas are decomposed in the producer, the composition of the gas is changed, the percentage of carbon dioxide and hydrogen is decreased, of the monoxide increased. As the hydrocarbons have a high thermal value their presence is desirable, especially if high temperatures are to be reached.

Some oxygen is also generally present in producer gas. Leaks and holes in the fire are mostly the causes of its presence. The rest of the gas is nitrogen, which, at dry gasification amounts to 60 per cent, at moist gasification to about 50 per cent.

The **International Acheson Graphite Company** is enlarging the output capacity of its branch works in Niagara Falls, Ont. This company has for many years operated a Canadian branch with facilities far in excess of the demands of the Canadian trade. It, however, recognizes in the hydro-electric and metallurgical development now so active throughout the Dominion and the new trade spirit and energy everywhere present throughout Canada an indication of additional industrial enterprise, and it is to meet the prospective demand for electrodes, etc., likely to be created by the new conditions that it is increasing the size and output capacity of its plant in Niagara Falls, Ont. A new furnace room, providing for a 1000-hp unit is being built, and on completion the new furnace installation will be placed in operation.

Furnace Electrode Losses.

By C. A. Hansen.

Previous work (*Proc. Am. Electrochem. Soc.*, 1909; also June issue of this journal, p. 270) indicated that when water-cooled graphite electrodes were used in the Acheson resistance type of furnace, increasing the thickness of the wall through which the electrodes pass, brought about a decrease in the electrode losses.

The explanation is, of course, that the heat conduction loss is greater than the C^2R loss in a short electrode, and since the

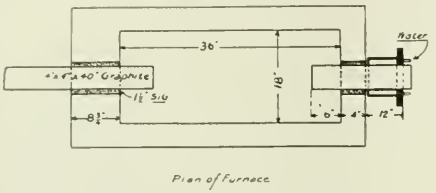


FIG. 1.—DESIGN OF ELECTRIC FURNACE.

heat conduction loss is inversely proportional and the C^2R loss directly proportional to the length of conductor, the sum of the two losses will be less for the longer electrode. There are, of course, limits both practical and theoretical to the extent to which this generalization can be carried.

As regards the practical side, we cannot purchase graphite electrodes greater than 40 in. in length, and while the 6-in. and 8-in. electrodes can be very satisfactorily joined together to give greater lengths, the smaller sizes, similarly joined, are not so satisfactory for ordinary furnace work. As regards the theoretical side, it is sufficient to say that an infinitely long electrode would have an infinite C^2R loss, and even though the heat conduction loss were zero, the sum would still be an infinite quantity.

This paper concerns a few experiments made with a view to determining the effect of electrode length on the electrode loss.

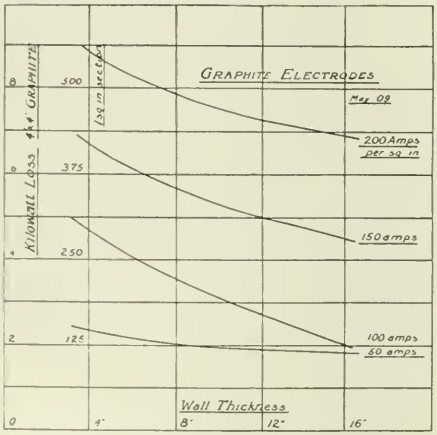


FIG 2.—CURVES OF ELECTRODE LOSSES.

Apparatus and Procedure.

Two small furnaces, such as shown in Fig. 1, were built. Each had inside dimensions of 18 in. x 18 in. x 36 in., with the four end walls respectively 4 in., 8¾ in., 13 in. and 15½ in. in thickness. The electrodes were 4 in. x 4 in. in section, projected 6 in. into the furnace, and were water-cooled. The water jackets were 12 in. long and were attached to the electrodes over the 12 in. immediately outside the furnace walls. (See Fig. 1.)

Current was measured by means of a 50 to 1 current transformer and Thomson inclined coil ammeter.

Electrode loss was taken from the cooling water, temperature being read on thermometers inserted in the outlet tubes and rate of flow by timing the filling of a 1000 cc. graduate with a stop-watch.

The two furnaces were charged with cracked carbon and they were joined in series so that all the electrodes would have exactly the same current going through them at any moment.

The intention was to make all comparisons with as nearly a constant difference in temperature between hot and cold ends of electrode as was possible, and to keep this temperature difference high, say, 2500 deg. to 3000 deg. C.

To this end, 600 kw-hours were absorbed in the two furnaces during a period of 2½ hours. The furnaces were then permitted to stand for 1½ hours before readings were taken, so that the heat stored up in the electrodes by the high currents previously used would not affect the results. A lower voltage (135) was then impressed and the following readings taken:

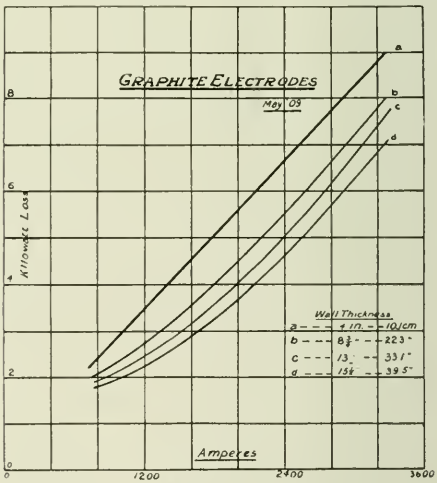


FIG. 3.—CURVES OF ELECTRODE LOSSES.

Time, minutes.	Current amperes.	Wall Thickness 4"	8.75"	13"	15.5"
		kw. loss.			
0	0	2.12	1.84	1.76	1.73
15	850	2.44	2.00	1.8	
30	1125	3.01	2.48	2.35	2.01
45	1250	4.07	2.58	2.48	2.33
60	1700	5.08	3.04	3.18	3.01
75	2025	5.35	4.23	4.00	3.49
90	2375	6.70	5.72	5.17	4.73
105	2900	7.87	6.82	5.57	5.68
120	3000	8.50	7.07	6.95	6.03
135	3200	9.40	7.20	7.15	6.86

Discussion.

The furnace charges were cooled locally at the electrodes during the 1½ hours in which no current flowed. The zero current loss with 4-in. wall thickness was only 2.12 kw in this case, while we found a loss of 3.58 kw when an idle 4-in. x 4-in. graphite electrode passed through a 4-in. wall under the conditions here prevailing at the 90-minute period.

The results cannot, then, be considered as relating to the conditions of equal temperature difference between hot and cold ends of electrode. The ratio $\frac{2.12}{3.58}$ would indicate a temperature difference of about 1600 deg. at the start between hot and cold ends of the electrode passing through the 4-in. wall. The temperature difference would be greater for the longer electrode, since, obviously, in the 1½-hour cooling period, they

conducted away less heat from the furnace interior. Any error introduced is then in favor of the shorter electrode. The temperature difference at the higher currents would be about the same for all electrodes and would approximate 3000 deg. C.

Due to the fact that the water terminals had a considerable water capacity, and pressure in the water mains fluctuated considerably, the results are not so regular as one might wish to have them. This pressure variable would affect all terminals alike, however, since they were all connected to the same main, and we find that each series of readings places the electrodes in the same order.

Calculated to percentage losses, the greater loss being taken as the unit, the results can be far more readily grasped.

Current, amps.	Wall Thickness 4" per cent loss.	8.75" per cent loss.	13" per cent loss.	15.5" per cent loss.
0	100	85.3	83.0	81.6
850	100	82.0	82.0	73.7
1125	100	82.5	78.2	66.8
1250	100	63.3	60.9	57.3
1700	100	71.7	62.7	58.2
2025	100	79.0	74.7	65.2
2375	100	85.3	77.2	70.8
2900	100	86.5	70.8	72.2
3000	100	83.0	81.8	71.0
3200	100	76.6	76.0	73.9

It is perfectly evident that the gain in increasing length of electrode is greatest at currents below 2000 amp—i.e., current density of 125 amp. Above this value the C^2R loss mounts rapidly with the current, and the gain in efficiency, by increasing wall thickness, is lessened. A reasonable interpretation of the results is given in graphic form in Figs. II and III.

To show how far the results are generally applicable to all electrodes of this type, the following comparisons between losses actually found with losses calculated from the curve sheets here given may be detailed.

Titanium Carbide Furnace.
Electrode 8" x 8" graphite. Wall thickness, 13".

	Current.	Current density, amps. per sq. in.	Loss observed.	Calculated.
1	10,000 amps.	156	22 kw.	21.2
2	14,500 amps.	227	28 kw.	34.4
3	20,000 amps.	312	36 kw.	. . .

The 20,000-amp loss requires too great an exterpolation of the curves given to make the calculation worth while.

Titanium Carbide Furnace.
Electrode 8" x 8" graphite. Wall thickness 9". Current, 10,000 amperes. C.D. = 156 amps. Calculated loss, 23.6 kw. Observed loss, 27.5 kw.

Graphite Furnace. (Separate experiment with another furnace).
Electrode 4" x 4" graphite. Wall thickness, 4¼". Current, 2520 amperes. C.D. = 157 amps. Loss, 6.98 kw. Calculated loss, 6.0 kw.

The agreement between observed results on 8-in. x 8-in. electrodes and those obtained by using the curves taken from the 4-in. x 4-in. electrodes is not perfect by any means, but the results so taken are at least fair approximations of the losses actually found and come much closer to the actually observed losses than values calculated from the resistance and heat conductivity figures at present available.

It is apparent from the data given that the efficiency of a graphite electrode, regardless of its length, within reasonable limits, of course, increases rapidly with increasing current density. Its efficiency increases also, as we have seen, with increasing length. It must be borne in mind, however, that the higher the current density the hotter becomes the electrode embedded in the furnace wall, and a limit is soon reached at which the refractories melt down.

As an example of this, we have found that at 10,000 amp an 8-in. x 8-in. graphite electrode and its 13-in. wall will last for 50 or more runs of 10 hours each—the wall failing, not the electrode. At 15,000 amp, with the same apparatus, the wall usually lasts four or five runs and occasionally twice that number. At 20,000 amp the furnace has repeatedly blown out around the electrode after running a few hours. The carborundum packing used was completely decomposed into spongy graphite and volatile silicon; the wall melted down about the electrode and was reduced at the expense of the electrode. Electrode and wall had, therefore, to be replaced, an expense per run, then, of approximately $60, which, of course, no power efficiency gain would begin to cover.

Increasing length of electrode at lower current densities will bring about the same result.

With carbon electrodes it would appear that increasing length of electrode would bring about a decrease of electrode efficiency, for the reason that the C^2R loss is much greater than the heat conduction loss, even in very short electrodes. This will, however, be worked out at some future time.

Research Laboratory,
General Electric Company,
Schenectady, N. Y.

Brooklyn Meeting of the American Institute of Chemical Engineers.

In our last issue we noticed briefly the semi-annual meeting of the American Institute of Chemical Engineers, held in Brooklyn, on June 24, 25 and 26. It was again a full success and especially the social functions, the dinner at Brighton Beach, and the excursions on Friday and Saturday, were greatly enjoyed, everybody being pleased with this feature of the meeting and the excellent arrangements. The program of the excursions was already given in our last issue.

At the subscription dinner at Brighton Beach some enthsiastic speeches were made by members and non-members. Dr. McKenna, Dr. Wm. T. Mason, and Mr. Stephen P. Sharples gave toasts for the Institute, while Prof. J. W. Richards spoke for the sister societies. The keynote of all the addresses was the function of the Institute. Professor Richards emphasized the fact that the Institute comprised a group of men engaged in technical work and that the technical application of scientific theories would be the field for its activity. He said that he had no doubts whatever as to the future of this sturdy infant of the chemical profession, that it was a natural growth and as such could not be suppressed.

We herewith give abstracts of the papers presented in the two sessions on Thursday morning and afternoon.

* * *

Prof. WILLIAM D. ENNIS, Polytechnic Institute, Brooklyn, spoke on the Efficiency Limits in the Power Gas Producer.

The difficulty of separately and accurately determining the efficiency of a gas producer suggests a computation of its efficiency limits. When pure carbon is converted into carbon monoxide, 30.69 per cent of its potential heating value is "transformed into temperature" and becomes unavailable for use in the gas engine.

By using a certain proportion of steam mixed with the air supplied for gasification the "temperature heat" may be partially employed in decomposing the steam. The hydrogen then carries this temperature heat to the engine as available heat of combustion. With sufficient steam supplied the temperature elevation might be eliminated, and the efficiency would be 100 per cent. Steam will not decompose readily at temperatures below 1740° Fahr., however, and the proportion of steam must be limited to that at which this temperature is attained. The efficiency is then, theoretically, 83 per cent.

A corresponding result follows the introduction to the producer ash pit of a portion of the waste gases discharged in the engine exhaust. The carbon dioxide then decomposes, and the heat absorbed is carried back to the engine. At the limiting temperature mentioned, the efficiency is 78½ per cent.

Modifying these results to include practical losses by radiation, fuel in ash, etc., variable specific heats of the gases, the presence of hydrocarbons in the fuel, the rise of surplus oxygen in the engine and in the producer, the initial temperature of the steam or waste gas and the formation of carbon dioxide, the maximum possible efficiency, with steam, appears to be less than 80 per cent, and with waste gas slightly less still.

Actual analyses of gases produced by the two methods check the computation to some extent. The conclusion is drawn that the temperature of the gas is the best crude indication of efficiency of operation.

The paper was discussed at considerable length.

A paper on the **Utilization of Low-Grade Fuels** was then presented by Dr. O. K. Zwingenberger, consulting engineer, of New York City. The paper is printed in full elsewhere in this issue (page 347).

During the recess at noon, Mr. Jerome Alexander made an interesting exhibition of the **Ultra-Microscope.**

In the afternoon sessions Dr. Samuel P. Sadtler, consulting chemist, of Philadelphia, and president of the Institute, presented a paper on **"Creosote Oil from Water Gas Tar."**

Dr. Sadtler gave a summary of the specifications for creosote oil used in the United States and Europe and showed that the present weight of opinion is in favor of the use of heavy oils rather than the phenols and naphthalene which have been specified in the past.

A resumé of the literature on the subject was given, and it was shown that a study of the creosotes recovered from timber which has been in service for periods ranging from nine to 47 years shows the presence of a very large percentage of oils boiling above 205° C.

The paper gave the results of the examination of a creosote fraction obtained from water-gas tar. This fraction is very similar to that obtained from the creosoting fraction of coal tar. While the author was not willing to express a final opinion on these results, but held them subject to confirmation by additional distillations, he did state that this grade of water-gas tar creosote may be quite specifically adapted to wood preservation.

A paper by Dr. Charles F. McKenna, consulting chemist, of New York City, on the **Centering of Great Industries in the New York Metropolitan District,** is published in full elsewhere in this issue (page 341).

Dr. J. C. Olsen and John S. Weiffenback, Polytechnic Institute, Brooklyn, described **Some Experiments on the Case Hardening of Steel with Gases.**

The authors gave the results of experiments on case-hardening of soft Norwegian iron with various gases, carried on at the Polytechnic Institute. It was shown that in most cases nitrogen in the form of ammonia facilitates the action of carbonizing gases. Nitrogen in the free state has no influence on the carbonizing action. It was shown that the ammonia does not react with the carbon gases to form cyanogen.

Carbon monoxide seems to act almost as well without as with ammonia. The depth to which the carbon penetrates and the percentage of carbon in the case were determined by analysis. The chemical reactions taking place during the carbonization were determined as follows:

With carbon monoxide, $2\,CO = C + CO_2$.

With methane, $CH_4 = C + 2\,H_2$.

With acetylene two reactions seem to take place, as follows:

$$2\,C_2H_2 = CH_4 + 3\,C,$$

and

$$C_2H_2 = C_2 + H_2.$$

The carbonizing ability of the gases studied ranges according to the following order: Carbon monoxide, acetylene, illuminating gas, methane. Carbon monoxide is by far the best gas for this purpose.

Mr. Richard K. Meade, consulting chemical engineer, of Nazareth, Pa., described **An Automatic Acid Egg,** in which the valve is opened and closed automatically by means of an electrical device.

Mr. J. G. Dean, of Exshaw, Alberta, Canada, described the **Method of Clay Control as Practiced by the Western Canada Cement & Coal Company, Ltd.**

The author described the method adopted to overcome the difficulties presented by the use of clay low in silica and high in iron oxide and alumina, rendered it necessary to add limestone to secure the proper silica-alumina ratio. As this proved unsatisfactory, a shale having a high silica-alumina ratio and a slate having a low ratio were mixed in the proper proportions to secure the ratio necessary for cement.

The arrangement of the bins and conveyors was described, and the formula used for calculating the proportions by which the materials are mixed; also formula for calculating the percentage of limestone to be added. On proper grinding a perfectly uniform quality of cement was produced which was in perfect chemical balance, having no erratic or freakish features.

New Norwegian Carbide and Cyanamide Works.

To complete our articles on the new calcium carbide and calcium cyanamide works at Odda, Norway, in our May issue, pages 212 to 216, and in our July issue, pages 309 to 313, we will describe the cyanamide furnace plant, the description being taken from London *Engineering,* June 11.

In the furnace house there are 196 electric furnaces capable of producing about 1 ton of nitrolime per week, each furnace taking three charges per week. These furnaces are arranged in rows of seven, as is shown in the perspective view, and the retorts they contain are transported between their position on the furnace benches and the charging-hopper by the overhead electric traveler.

On being returned to their furnace, the necessary connections are made for the supply of nitrogen and for the electric current, which is passed through central carbon resistances in order that a temperature of from 800 deg. C to 1000 deg. C. may be secured to induce nitrification. The nitrogen to be combined with the carbide (delivered at the rate of about 13,000 cu. ft. per hour) is supplied to these retorts through mains from the Linde house already described, a large meter being interposed in order to control the pressure and supply. There are also at each furnace suitable regulating valves and small control-meters.

The absorption of the nitrogen occupies some 30 to 40 hours, and care has to be exercised to ensure a uniform temperature so as to finally fix the required percentage of nitrogen in the nitrolime. The calcium carbide powder has in the process been converted into an exceptionally hard substance, not unlike coke in appearance, and has at the same time contracted considerably in volume, so that its removal from the retort is not difficult.

It has, however, first to be cooled, and the retort, for this purpose, is allowed to stand from 8 to 12 hours on a grid, under which a current of cold air is passed. The contents are afterwards fed into the hopper in the cyanamide-grinding house.

Exception has been taken to the process because of the small contents of the retorts, and the assumption that this involved a large amount of manual labor. Experience, however, made the use of a small furnace practically imperative, as thereby alone thorough reliability in the finished product can be attained.

It became a comparatively simple matter to devise means to economize the amount of labor involved. The motive power is cheap, and ingenuity has enabled the general arrangements of the plant to be such as to involve a minimum of handling. Forty-five men suffice for the furnace-house, and these men work in three shifts, so that the labor cost for over 200 tons of nitrolime is little more than $3 to $3.25 a ton.

The subsequent grinding of the nitrolime is carried out in a special grinding house, the material being delivered there by conveyors, which feed a gatemill, whence elevators and worms take it to hoppers discharging into ball mills. It is led by worm conveyors into elevators, which ultimately deliver it into the silos.

The Odda carbide and cyanamide works are supplied with three-phase currents from the Gysse station at 11,000 volts, the total power being 20,000 electrical horse-power. The larger part of this energy is used for the electric control furnaces.

There is a primary switchboard having 14 switches, 12 of which are respectively for the 12 furnaces. Another is for controlling the current to the cyanamide works, and one more for passing the current to the low-tension station, to be referred to later. A single-phase static transformer is located directly

under each carbide furnace, and the voltage is reduced from 11,100 to 50, giving a current of 28,000 amp. Each furnace transformer is placed between two phases, and these are interchangeable, so that there is no possibility of a complete stoppage owing to failure of the electric current. The transformers are cooled by induction fans, which draw their current through the

CYANAMIDE FURNACE BUILDING.

tunnel, so that the temperature of the air is considerably below that of the atmosphere.

The low-tension transformer is also of the static air-cooled type, and reduces the voltage to 400. The current is subsequently controlled at a switchboard. A large part of the three-phase current of 400 volts is used for driving the workshops and large motors. The remainder is converted into direct current at 220-volts pressure, which again has a separate switchboard and the current is used for lighting and for driving the small power motors, the electric railway locomotive, and the small wagons on the telpher railway.

Dwelling houses have been erected for the workmen, about 200 yd. from the factory. Twenty have already been completed, each for four families.

The earnings of the workmen vary from 80 kr ($21.44) up to 150 kr. ($40.20) per month, with an average of about 100 kr ($26.80 per month). The companies try for the most part to employ married men, as they are quieter and more conscientious in their work. The works are associated with the State insurance establishment for workmen, so that they are insured in case of accidents, and a sick club is likely to be established.

"The companies have succeeded in their endeavor not to spoil the amenities of this beauty spot in the Soldal Fjord. The works have greatly added to the prosperity and well-being of the population, and the evidences of commercialism are neither obtrusive nor unpleasant, certainly not more unpleasant than the suggestion of poverty and hardship which exist in so many of the Norwegian hamlets, and which may, as at Odda, give place in the future to active and prosperous industry."

Notes on Electrochemistry and Metallurgy in Great Britain.

(From our London Correspondent.)

Iron and Steel Institute.

A brief account of the spring meeting, held May 13 and 14, in London, has already been given in our June issue, page 280. In the following we give an account of the discussions

Corrosion of Steel.

The three papers on "The Electrolytic Theory of the Corrosion of Iron and Its Applications," by Dr. W. H. Walker, of Boston, Mass.; "The Preservation of Iron and Steel," by Dr. A. S. Cushman, of Washington, D. C., and "The Value of Physical Tests in the Selection and Testing of Protective Coatings for Iron and Steel," by Mr. J. Cruickshank Smith, were read and discussed collectively. Concerning the electrolytic theory of corrosion of iron and steel and the part which Dr. Cushman and Dr. Walker have taken in the development of this theory a vast amount of information has been published in our last two volumes.

Mr. J. E. Stead opened the discussion, and conducted some of the experiments demonstrating the passive condition of steel produced by potassic bichromate. He considers the author's methods to be a beautiful illustration of the electrolytic theory and quite convincing. Dr. Cushman had omitted mentioning the remarkable effects of a slight amount of impurities on steel, but bearing these in mind, it was easy to understand how corrosion was set up. With regard to Dr. Walker's references to segregation effects, the segregation of the carbon in small masses of pearlite, which were quite different from ferrite, set up a condition of electrolytic tension in the steel with consequent formation of electrolytic couples on the surface. Although segregation always occurred below the suface, pitting resulted on the surface; and this indicated that pitting was not dependent on segregation, but resulted from the way in which the anodes and cathodes formed couples. He had tested English tin plates by the electrolytic methods, and the results proved their superiority over American plates. He had noticed that when steel plates for ships were marked whilst hot the paint had a much enhanced effect in preventing corrosion; and he held the view that protective paints should be applied to the plates while in a heated condition, so that moisture was entirely eliminated. Every practical engineer knew that plates painted hot lasted longer than those which had been painted cold.

Mr. E. A. Saniter said he should like to see a complete analysis of the especial kind of iron dealt with in Cushman's paper and stated to contain 99.5 per cent of iron. With regard to Dr. Cushman's reference to corrosion tests with acids, practical experience demonstrated that steel which was most attacked by sulphuric acid in laboratory experiments was least affected in actual use in the open.

Mr. B. Philips Smith eulogized Walker's attitude in setting forth the theory and details of his experiments without deducing therefrom any specific conclusion inimical to a particular commercial process, as Cushman had done, who from results of laboratory experiments formulated an attack on graphite pigment as a substance promoting corrosion; but tests of pigments with an aqueous vehicle afforded no information as to the action of such pigments mixed with linseed oil, as they were in actual use. To arrive at true conclusions experiments should be conducted more carefully and with regard to normal conditions.

He remembered an expression of opinion that because ferromanganese—which was a carbide—decomposed water, less than 1 per cent of manganese in steel would act similarly and increase liability to corrosion. Yet Hadfield's manganese steel

metal containing 13 per cent of manganese was not so easily corroded as iron. He believed that a Mr. Cushman was responsible for the opinion in question, and he wished to know if that Mr. Cushman was the author of the paper under discussion. Mr. M. P. Wood had pointed out that graphite pigments were electro negative and less susceptible to catalytic or electrolytic action than any other class of pigments with the exception of lampblack. The careless use of iron oxide and of compounded pigments was the cause of much corrosion in important iron structures. Mr. Cushman appeared to have overlooked the importance of the nature of the vehicle, and the value of a correct description of graphite paint was not diminished by Cushman's finding that some kind of graphite, not specified, did not, when mixed with water, give protection to a knife blade.

Professor Turner said he was not prepared to go all the way with Mr. Cushman, but found points on which he could agree. Attention has been drawn by numerous observers—including Dr. Tilden—to the effect of small quantities of foreign bodies on the surfaces of metal. Mr. Stead had called attention to the importance of using well-boiled tar or oil, which was much more effective than if applied cool.

Mr. G. H. Strick, as a maker of tin-plate, remarked that imperfections were mainly due to faults in the metal previous to tinning. Recently more attention to the securing of a good, clean surface had resulted in an improved production.

Mr. F. A. Willcox asked if experiments had been made with a paint containing a celluloid base. He had used a solution of celluloid in amyl acetate to prevent pitting in propeller blades, and the samples had remained in good preservation for 10 years, except at the tips.

Mr. Cushman then replied: He had advised American manufacturers to pay more attention to quality than to quantity, and some had followed his advice and consulted him, with the result that several mills had adopted new methods. He would seek to eliminate the impurities which were now allowed in their plates, although he was aware that in doing so other troubles were introduced. They must think of something more than turning out a quantity of metal and selling it. The 99.5 per cent iron referred to contained only traces of arsenic, copper, and other impurities which had been mentioned. He agreed that the acid test was not fair. Its action was quite different from that of the atmosphere, which was quiescent and gradual. Aluminium, if properly used at a correct temperature, left no oxide in the metal. The prohibition of the use of artificial coloring matter to counteract the sickly color of the fruit syrups caused by the tin, in canned goods, led to the reduction of the tin coating on the iron to an extent which resulted in the cans being perforated by the acid fruit juices which squirted through the pinholes they had caused. The application of Dr. Walker's ferroxyl test to tin plates gave possibilities of great advances. It was essential in this test to ensure absence of dust. With regard to celluloid paints, he had made many experiments with amyl acetate and with chromatised paints, but his most successful lacquer he made by adding chromic acid, in small quantities at a time, to an alcohol solution of shellac, and this had given excellent results as protective for steel surfaces.

The president, Sir Hugh Bell, moved a vote of thanks to the authors and said he appreciated Mr. Cushman's sub-acid remarks concerning American productions all the more because they were directed on Americans by an American. He also wished to thank Mr. Cushman for his side remarks on the subject of waste—a question of very vast importance to those living to-day—for, if waste could be reduced, 10 per cent of all those conditions which statesmen and others were seeking to remedy could be removed. The question of the preservation of iron and steel was of the utmost importance; for the extent to which buildings depended on these materials for their mainstay was great and continually growing, but immense structures were being erected under conditions of ignorance as to what changes the future might bring forth. Mr. Walker had emphasized the necessity for adequate protection of the iron reinforcement of concrete, and the desirability of the concrete being dense and impervious to water. He asked those present to consider whether due precautions were being observed in the use of reinforced concrete in modern iron buildings, and whether there were not a possibility of some serious disaster occurring soon in connection with buildings of that class.

A paper was then presented by Prof. E. Heyn and O. Bauer on the influence of the treatment on the solubility of steel in sulphuric acid, and deductions therefrom as to the nature of the treatment to which it had been previously subjected.

The discussion of this paper was opened by Mr. Stromeyer, who said that he was greatly interested in the fact demonstrated by one of the diagrams that heat treatment was effective at so low a temperature as 100 deg. C., because he had no doubt about such changes occurring at even still lower temperatures. Much of the ground he had gone over on the ageing of steel was covered by the paper. He maintained that a complete reproduction of the ageing effect could be obtained by boiling steel for 15 minutes, but the paper made it appear that much more prolonged boiling would be requisite.

Mr. J. E. Stead remarked on the effect of crushing steel in producing physical change leading to liability to oxidation. The work the authors had done confirmed previous researches on the solubility of steel, and they appeared to prove that the critical point in annealing was 400 deg. C.

Dr. W. Rosenhain considered that the description of the results obtained by heating steel above and below 400 deg. C were most instructive and valuable. The authors believed they had discovered a new constituent of steel, which they had named osmondite, but he thought that the extension of the list of names was not desirable, and would not be of assistance in explaining observed phenomena. Below 400 deg. C. the metal might be considered to consist of martensite and troostite, and at that temperature there was disappearance of martensite and initial pearlitic metamorphosis.

Mr. Saniter thought that the reliability of the authors' analytical methods was established by the results. It appeared that residual carbon was at a maximum at 400 deg. C., when formation of sorbite began, while at 600 deg. C the hardening effect of quenching was eliminated. His own experience agreed with this.

Decarburization of Iron.

Mr. W. H. Hatfield presented a paper on "the chemical physics involved in the decarburization of iron-carbon alloys." The question at issue is the theory of Wüst that in the decarburization of white iron it is essential that the carbon be out of solution (or combination) as temper carbon before the action of the oxidizing influences which are to eliminate it can take place. Mr. Hatfield strongly denies this theory. In his opinion it is not necessary that the carbon be precipitated as temper carbon before its removal. Should temper carbon be produced, it is most likely that only that temper carbon which has recombined with the iron by diffusion, can be removed.

Mr. J. E. Stead led the discussion by briefly remarking that his personal experiences induced him to consider that Mr. Hatfield's conclusions were established.

Prof. G. Turner agreed generally with the author; but there was one point—a small matter—on which he differed, viz., that the percentages of sulphur were the same in converted and in unconverted bars, for he found sulphur was diminished. He had never found precipitated carbon present during the process of elimination. Some years since, he had pointed out, in a paper, that the separation of graphite from cast iron was accompanied by evolution of heat; but more heat was evolved in burning the carbon out of the iron than in the combustion of the carbon alone.

Mr. E. Adamson said Mr. Hatfield's results were in accordance with some of his own.

Prof. A. McWilliam remarked that it was usual to consider

that no good could come out of Sheffield, while all that came from Germany was approved. But he thought Mr. Hatfield had demonstrated the correctness of the older views on the subject, and that Dr. Wust had got shunted on a side track in the matter.

Mr. Hatfield, in his reply, said his work had been done to ascertain the correctness of the views held on the subject, and he was much gratified to know that Mr. Stead, Professor Turner, Professor McWilliam and others agreed with him. As to the point raised by Professor Turner on the sulphur content, the figures given were actual determinations; but in view of existing evidence that the annealing of malleable iron did diminish the sulphur, he intended to give further attention to the question.

Electric Steel Furnaces.

The second day of the meeting brought Mr. W. Rodenhauser's paper on "the electric furnace and electric process of steel making," and an interesting discussion followed.

The discussion was opened by Mr. Arthur Windsor Richards, who said that where conditions were favorable to the supply of cheap power, no doubt the electric furnace had come to stay, at all events for high-class steels; but the electric production of steel must be effected more cheaply before it could compete with the Bessemer and open-hearth processes. It was true that analyses showed that electrically produced steel was very good, but its cost was very great, and that led to the consideration of a point in the manufacture of the rail steel which the author had produced in the Roechling-Rodenhauser furnace. The blown metal contained 0.08 per cent of phosphorus and 0.1 per cent of sulphur, and in the furnace these amounts were reduced to 0.023 and 0.044 per cent, respectively. Physical tests had shown that that material was very satisfactory, but steel fully equal to it was being made by the basic open-hearth process at a much lower cost. He asked if the author had intentionally stopped the process when the percentages of phosphorus and sulphur were reduced to the figures just given. If so, he quite agreed that it was neither necessary nor beneficial to reduce those substances to a lower quantity in rail steel with high carbon. If the arrest at the point was not intentional, was that so because he failed in the reduction in consequence of the heat of the induction furnace not having been sufficient? It had been said that the high qualities of electric furnace steel were not entirely due to the small percentage of impurities in it. He thought they were accounted for by the nearly total absence of gases—mostly nitrogen and oxygen—combined or mixed with the metal.

Mr. J. Gledhill concurred in the view that the advent of the electric furnace opened up for makers of steel a new vista. He thought, however, that questions of cost were the main factor, and that electric smelting was not likely to compete satisfactorily with the other processes. His own firm had been recovering the by-products—chiefly ammonium sulphate—and had consequently considerably reduced the cost of smelting. Practically, a ton of coal yielded 80 lb. to 90 lb. of ammonium sulphate, worth £11 to £12 per ton. The coal cost 9s. to 10s. per ton, and the economy was manifest. He admitted that the electric furnace produced an excellent material, but he wished to point out that the ordinary processes produced an equally good material. He believed that there was a great future for the electric furnace, but much remained to be done before it could compete on the large scale with existing processes. Information as to first cost and depreciation was desirable for comparison with those of ordinary plants.

Mr. Otto Frick did not agree with some of the author's points. The main reason why the Stassano furnace was unsuitable for large charges was the position of the electrodes, and the longer electrodes in the larger furnaces were more liable to break. The author had said that in the Girod furnace the consumption of energy was more constant and the generators consequently worked under better conditions. That was hardly correct; the variation in the energy required was due to short-circuits between the electrodes and the steel. In the case of a 300-kw furnace, quoted by the author, the heat produced by the passage of current through the steel was only the equivalent of about 10 watts, or 0.033 per cent of the total energy. The contention of the author that in arc furnaces the charge was almost entirely heated by the arc was certainly correct, but in these furnaces the heat developed in the arc first heated the air or gases in the furnace from which it was conveyed to the metal through the slag.

A furnace of the Frick type was in regular work at the Krupp works, Essen, since August last, with a capacity of 10 tons, consuming 1000 hp, and such satisfactory results had been produced that Krupp's had secured exclusive rights in the German patents. The author said that the shape of the hearth in the Frick furnace prevented the removal of slag, and that these furnaces were only adapted for pure materials. That might be true of the Kjellin furnace, but not of the Frick furnace, which had the cover of the crucible in one piece and capable of rotation in such manner that every part could be inspected through one opening. It was easy to bring the slag to the spout with the skimmer and draw it out, but he did not recommend this way of slagging, but preferred to entirely empty the furnace into a ladle and to return it from the bottom of the ladle, leaving the slag in that. By this method a much more complete separation of the slag from the metal was effected. The author claimed, too, that the first cost of the dynamo was lower than in the Frick system, but the difference was unimportant; and the lower radiation losses in the Frick system would be equivalent to a saving of 15 per cent per annum in working expenses where current cost ½d. per unit. He believed that the best economical results would be achieved by the electric furnace as supplementing the Bessemer and Siemens-Martin furnaces. The efficiency was much the same as that of a Siemens furnace.

Mr. Hiorth said that the annular parts of the Roechling-Rodenhauser furnace bath represented a double furnace similar to the Kjellin, i.e., the bath was heated by pure induction currents at a low pressure of 8 volts to 12 volts, while the rectangular bath was heated by currents of higher voltage between the terminal plates. The currents of higher voltage had to traverse copper, iron and a layer of refractory material, and was the loss of energy less than with carbon electrodes in an arc furnace? In consideration of the very high efficiency of the Roechling-Rodenhauser furnace, given as 97 per cent, it seemed that the consumption of energy in the annular parts of the bath was very small. That part of the bath incurred great loss of energy owing to the extent of its radiating surface, and there was a danger of the steel breaking through the wall.

Why retain the induction principle at all when it reduced efficiency electrically, thermally and practically? He agreed with the author that the Kjellin furnace was not suited for large capacities, and even with a five-cycle, alternating current a 10-ton furnace would never be efficient. The ideal steel furnace for large charges was apparently the "pure induction" plant constructed closely in conformity with the ordinary transformer, namely, with the primary windings as close as possible to the bath. From his own experience in working a 500-kw furnace he considered it possible, with a three-phase current and a good power factor, to smelt 40 to 50 tons at a time. The "pure induction" furnace was, he thought, the best solution of the problem.

Professor McWilliams said that he and the electrical expert of the metallurgical department of the Sheffield University had examined the working of the Kjellin furnace. A furnace had been purchased, and experiments were going to be carried out. The cost of the electric furnace was not the most important matter; the quality of the product was of consequence. That question had arisen in connection with one important company which was giving a higher price for steel rails finished in the electric furnace after having been made by the open-hearth furnace.

SYNOPSIS OF PERIODICAL LITERATURE

Coal Dust and Mine Explosions.—Before the Congress of Applied Chemistry Prof. Galloway read a paper on "Coal Dust," reviewing the subject, and his efforts to obtain recognition from the official inspectors of mines in England for the dangers due to this cause, with some details of the methods now used for minimizing the danger. The use of dust-tight wagons for hauling purposes, and of damping the floor of the mines at regular intervals, were two of the remedial proposals suggested by the author, and he also suggested the use of hydroscopic salts or "stine" dust for this latter purpose. This proposal had recently formed the subject of experimental trials at Normanton, in Yorkshire, and at Lievin, in the north of France. It had been suggested, further, as a means for preventing the spread of explosions from one part of the mine to another, that a certain length of each roadway should be lined with brick or concrete and kept always wet. The Royal Commission on Mines, which was sitting, was considering these and other proposals for minimizing the special dangers due to the presence of coal dust in mines. A second paper on this subject was prepared by Berg-Assessor Forstmann and related to the study of the same question in the Westphalian coal mining area in Germany. Since Jan. 1, 1899, certain mines in this district have adopted sprinkling methods for keeping the coal dust moist. In some cases a special network of water pipes had been installed along all the galleries and working places of the mine, and special men had been appointed to look after this work. Although explosions had occurred in these mines since the date named, the author considered the sprinkling method was the best of those proposed for minimizing the dangers due to coal dust.—(*The Engineer*, London, June 11.)

Alloys by Electrodeposition.—A paper read before the Faraday Society on June 29 by Mr. S. Field deals with "the conditions which determine the composition of electrodeposited alloys." In the present paper the author deals with copper-zinc alloys. As the result of a large number of experiments on the electrolytic deposition of brass, he has, by the analysis of the deposits, shown the regular manner in which the composition changes with such varying conditions as (1) proportion of copper and zinc compounds in the solution; (2) strength of the solution; (3) temperature; (4) current density, and (5) the presence of free cyanide. It is thus shown that the proportion of zinc is increased (*a*) at lower temperatures; (*b*) with more dilute solutions; (*c*) with increased current density, and (*d*) by the absence of free cyanide. With a large proportion of zinc compound copper is still freely deposited. The author incidentally draws attention to a number of important conditions which primarily affect the composition of the solution and ultimately the character and composition of the deposit. The work is being continued on other binary alloys. (From advance sheets.)

Electroanalysis.—At a meeting of the Faraday Society, held on June 29, Dr. Henry J. S. Sand read a paper on "Apparatus for the Rapid Electroanalytical Separation of Metals." The paper contains a description of some developments made in the apparatus, first described by the author about two years ago, for the rapid electroanalytical depositio nand separation of metals [*Chem. Soc. Trans.* 91, 373 (1907); also *Trans.* 93, 1572 (1908)]. This apparatus combined in a practical manner the use of an auxiliary electrode and very rapid stirring of the electrolyte, and made it possible to deposit and separate from each other for purposes of chemical analysis the metals silver, mercury, copper, bismuth, lead, cadmium, zinc, antimony, and tin. The times required for these depositions varied in the majority of cases between 5 and 15 minutes. Apart from the very high stirring efficiency of the electrodes the apparatus is believed to be superior to others of similar type in the very great simplicity of the method of making and undoing the electrical connections on a single stand, in the fact that the electrodes may be used with ordinary beakers, and in the simple manner in which the electrodes may be washed and dried. No alterations in principle have therefore been made to the apparatus, but the following additions and simplifications are described.

As hitherto, a mercury contact has been employed in the electrolytic stand to make the connection between the stationary and the moving parts; a special screw cap has, however, now been provided, which may be screwed down when the apparatus is not in use, making it possible to transport it without taking out the mercury. A clutch arrangement has been added which enables the operator to start or stop the rotation of the anode without stopping the motor. Such an arrangement will be found of advantage if it is desired to actuate several sets of apparatus from one shaft driven by a single motor; or if the current is obtained from a small motor-generator which is also employed for rotating the electrode, the clutch making it possible to stop or start the stirrer without stopping the current; or lastly, if a hot air or water motor is employed which cannot be stopped instantly during the washing of the electrodes. A very considerable simplification has been obtained by fitting all the apparatus required for the measurement of the potential of the electrode in a single box. The arrangement has been designed so that by depressing a key it will also allow the potential difference between the anode and the cathode to be read directly. It was thought very desirable to retain the capillary electrometer as a zero instrument, but it became necessary to design a new portable form suitable for the purpose in view. It may be described as a closed evacuated form developed from the Ostwald horizontal capillary electrometer. It is provided with an enclosed scale, and if observed by a lens of small magnification it will readily indicate one millivolt. (From advance sheets.)

Platinum Thermometer.—C. W. Waidner and G. K. Burgess, of the Bureau of Standards, have carried out an experimental investigation on the platinum thermometer at high temperatures and presented the results before the Physical Society. Our abstract is taken from the *Physical Review* of June. The authors investigated the applicability of the Callendar formula for the calibration of platinum thermometers, in the range 0 deg. to 1100 deg. C., for platinum of different degrees of purity. Platinum temperatures are numerically defined in terms of the resistance of platinum as follows:

$$pt = 100\,(R - R_0) \,/\, (R_{100} - R_0),$$

and the difference between platinum and gas scale temperatures is given by the formula:

$$t - pt = \delta\,(t/100 - 1)\,t/100$$

The fundamental interval $F.I.$ is evidently $R_{100} - R_0$, and the fundamental coefficient, $c = (R_{100} - R_0)/100R_0$. The constants δ and c are characteristic of the material of the thermometer. Calibrations are made at 0 deg., 100 deg., and 444.70 deg. C. (the boiling point of sulphur) giving the values of R_0, R_{100}, and R_s, respectively, from which data any other temperature may be computed from the observed resistance R.

Nine platinum thermometers were used of wire, varying in diameter from 0.1 to 0.6 mm and having a range of R_0 from 0.11 to 21.3, of c from 0.0039 to 0.0017 and of δ from 1.50 to 1.80. The thermometers were of the compensated and of the potential lead types; some of the measurements were taken by a potentiometer method, some by means of a special Wheatstone bridge, and some of the thermometers were adapted to measurements by three methods, the potentiometer, the Wheatstone bridge, and the Kelvin double bridge. The resistance measurements were made to 1 or 2 parts in 100,000.

The metals were used in crucibles of pure graphite with powdered graphite covering them and in amounts of 1.5 to 2 kg, ensuring ample depth of immersion of the coil and of the thermometer. The melting and freezing point determinations were carried out in vertical electric resistance furnaces wound with two platinum ribbon heating coils on concentric porcelain tubes, the windings being so spaced as to give quite uniform temperature distribution throughout a considerable length of

the furnaces. The temperature could be maintained constant to within a few hundredths of a degree for many minutes at a time during the freezing or melting of the metal. By stirring with the thermometer, under-cooling could be practically avoided. The results of the freezing point determinations are shown in the table.

It will be seen that for pure platinum, for which $\delta = 1.50$, the Callendar equation is in agreement with the generally accepted gas scale to within the limits of reproducibility of the latter, or 1 deg. C., but for impure platinum this equation no longer holds good.

The effect of high temperatures on the constants of platinum thermometers is in general to reduce the value of R_0 and increase *F.I.* The effect on δ is very small. Measurements made with pure platinum thermometers of heavy wire (diameter = 0.6 mm) without the usual mica-supporting frame, show unusually small changes in R_0, even after several heatings for some hours at 1250 deg. changes equivalent to only a few tenths degree C.

Thermometers of pure palladium were also tried, for which $\delta = 2.89$ and $c = 0.00336$. They do not satisfy the Callendar equation; for example, it leads to a value of 1152 deg. C. for the *F.P.* of copper. The effects due to heating are similar to those found for platinum.

Four *Pt*, *Pt—Rh* thermocouples, of slightly differing composition calibrated in terms of the equation $T = a + bE - cE^2$ at three of the freezing points in the table (Zn, Sb, Cu or Zn, Ag — Cu, Cu), as given by the platinum resistance thermometer, agree with each other to within 0.3 deg. at intermediate temperatures, and to within 1 deg. with the scale as defined by the thermometer of pure platinum.

Temperature.	Platinum, mean.	Platinum, actual.	$MgCaSi_2O_6$ mean.	$MgCaSi_2O_6$ actual.	$CaSiO_3$ mean.	$CaSiO_3$ actual.
100°	.....	.....	0.1926	0.2050	0.1833	0.1916
500	0.03351	0.03560	.2310	.2668	.2170	.2510
700	.03425	.03685	.2420	....	.2288	....
900	.03515	.03799	.2490	.2810	.2355	.2604
1100	.03575	.03901	.2563	....	.2400	....
1300	.03644	.04003	.2600	.2800	.2420	.2510
1500	.03679	.04073	....	....	....	....

temperature. The accidental variations of the results were thus brought in nearly all cases below 0.5 per cent, usually below 0.2 per cent. The systematic errors are probably not much larger, but are to be further investigated. Meanwhile, the results seem trustworthy, to 1 per cent, except above 1400 deg., and as little is known of specific heats in the region covered, a preliminary publication of some illustrative substances is now given. The temperature scale was determined from experiments still in progress at the Geophysical Laboratory, and does not contribute appreciably to the systematic error, except again, possibly at the highest temperatures. The following values for platinum and two pure crystalline silicates are of the mean specific heat from 0 up, which was directly determined, and of the actual specific heat at each temperature, derived from this. The results for $CaSiO_3$ are within 1 per cent of those obtained a year ago. These data agree within 0.5 per cent, in most cases much closer, with the following formulas for the mean specific heat:

$$\text{Pt. } 0.03198 + 3.4 \times 10^{-6} T \text{ or } 0.03198 + 3.967 \times {}^{-6} T - 4.67 \times 10^{-10} T^2$$

$$CaMgSi_2O_6\ 0.1779 + 1.516 \times 10^{-4} T - 1.047 \times 10^{-7} T^2 + 2.81 \times 10^{-11} T^3$$

$$CaSiO_3\ 0.1722 + 1.18 \times 10^{-4} T - 6.16 \times 10^{-7} T^2 + 9.4 \times 10^{-12} T^3$$

The linear equation for platinum is the more convenient, the

SCALE OF PLATINUM THERMOMETER—CALLENDAR FORMULA—CALIBRATION DATA
(S = 444° 70C.)

Metal	$\delta = 1.505$, $c = 0.00383$ to 390 — Temp. Calc.	Range Deg. C	Number of: Obs.	Samples	Thermoms.	$\delta = 1.570$, $c = 0.00206$ to 210 — Temp. Calc.	Range Deg. C.	Number of: Obs.	Samples	Thermoms.	$\delta = 1.803$, $c = 0.00173$ — Temp Calc.	Range Deg. C	No. of Obs.	Gas Scale Holborn and Day
Sn	231.92	0°.04	4	1K	2									
	231.89	.09	6	3	2	231.82	0°.08	4	3	1				
Cd.	321.01	.09	3	K	2	320.95	.02	2	1	1				321 7
Pb.	327.58	.01	2	1	1									326.9
	419.37	.04	6	K	1	419.32	.08	8	3K	1				
		.11	9	3	1		.16	11	5	1				419.0
Zn			$\delta = 1.516$				$\delta = 1.551$		K	1				
	419.30	.09	5	K	1	419.28		1	3K	1	632.65	0°.09	2	630.6
Sb	630.71	.57	7	3K	2	631.25	.17	4	3K	1				
M. P.	630.80	.15	4	2K	1	631.06	.08	3	1	1				
Ag–Cu, 71–29	779.55	.08	3	1	2	781.21	.06	2						
Ag–Cu, 72–28	779.18	.45	6	1	3						784.61	14	2	
Ag–Cu, 73–27	779.23	.30	3	1	2			1	1	1	975 28	08	2	961.5
Ag.	960.88	.39	8	1	3	966.21	.02	2	3	1	1106 2		1	1084 1
Cu	1083.04	1.61	7	B C W.	3	1091.92	1.15	4						
	1082.88	2.26	13	4	4									

In the table "range" = difference between highest and lowest *F.P.* determinations. "Number of samples" refers to materials from different chemical firms. "K" means Kahlbaum, "B. C. W." the Baltimore Copper Works' purest product.

Specific Heats at High Temperatures.—At the Washington meeting of the Physical Society a paper was presented by Walter P. White, of the Geophysical Laboratory of the Carnegie Institution of Washington, on specific heats at high temperatures. Since this is a matter of great importance for making chemical and metallurgical calculations, we give the full abstract from the *Physical Review* of June. A year ago, specific heat determinations at high temperatures were described in which the hot bodies were dropped from an electric furnace into a calorimeter. The calorimeter errors were negligible. The heat loss in transit was compensated and thus reduced purely to an accidental error, which the agreement of the results shows to have been very small (0.1 per cent or less). The preponderant source of error was the difficulty of obtaining uniform temperatures in the electric furnace. A longer and narrower furnace was therefore constructed, in which radiation shields above and below the charge increase the uniformity of other probably nearer the truth; their difference is well within the possible error.

If $A + BT + CT^2 + DT^3 + \ldots$ is the expression for the mean specific heat, the actual specific heat is given by $A + 2BT + 3CT^2 + 4DT^3 + \ldots$ but the actual heats thus determined contain the errors of the mathematical expression in an exaggerated degree, hence those here given for the silicates were obtained graphically. Even so, they are less accurate than the mean heats, especially at the higher temperatures (an error of 1 per cent in the mean heat at 1500 deg. may produce 1 of 7 per cent in the true heat). The apparent decrease in the silicate specific heats above 900 deg. must, therefore, not be given undue weight; but the general character of their specific heat curves, whose increase is mainly at comparatively low temperatures, is unquestionable and in striking contrast to platinum.

Quartz shows the same type, even more strongly marked, but the inversion at 575 deg., which causes a heat evolution of from 4 to 5 calories complicates the treatment of the data, and will necessitate further observations. The mean heat, 0-500 deg., is 0.2370, which is very much lower than some published values.

RECENT METALLURGICAL AND ELECTROCHEMICAL PATENTS

General Electrochemistry

Polyphase Furnace.—A rectangular three-phase furnace, as shown in Fig. 1, is patented by H. C. Harrison, for instance, for the manufacture of ferrosilicon. There are three electrode bundles 9, each bundle consisting of four electrodes, and being connected to one phase of the three-phase system. The charge 2 (silica, iron or iron ore, and coke for the manufacture of ferrosilicon) is introduced from the top. The molten ferrosilicon 3 collects on the bottom. The charge 2 above is of relatively low conductivity compared with the molten ferrosilicon 3 below. It is, therefore, possible to maintain three arcs always between the ends of the electrode bundles and the molten ferrosilicon below, and never between the electrodes themselves. The bath 3 is grounded through the refractory bottom lining 7 and metal bottom 6. In the same way the neutral point of the three-phase generator or transformer is grounded. The three electrode bundles are spaced just far enough apart to cause the molten

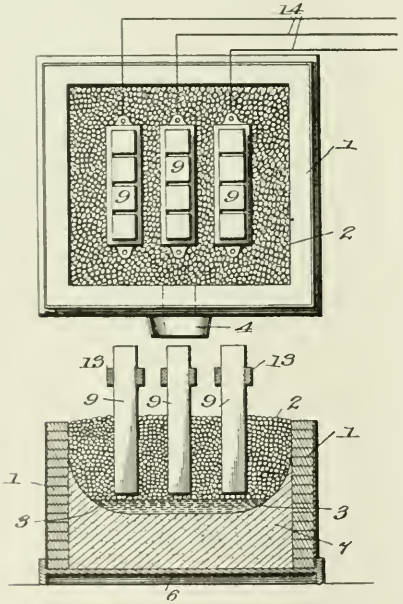


FIG. 1.—THREE-PHASE FURNACE.

bath to be always one and not three separate baths, so that only a very small current passes from one electrode to the other through the unreduced charge. When single electrodes, instead of electrode bundles are employed the furnace must be narrower. The inventor emphasizes that his furnace is quite different from three-phase furnaces working on the resistance principle, where the electrodes must be placed symmetrically in regard to the neutral point and when the furnace should be itself circular. In the present furnace it is not "essential" to arrange the electrodes symmetrically with respect to the neutral point: "it is only necessary to balance the phases by a careful regulation of the arcs maintained between each electrode and the (electrically) neutral bath." (919,165, April 20, 1909.)

Artificial Graphite.—E. G. Acheson, the founder of the artificial graphite industry, had formerly found that for the charge of amorphous carbon into graphite in the electric furnace it was advantageous to mix the carbon with materials capable of forming carbides. He has now discovered a process whereby carbon devoid of such carbide-producing materials may be converted into the graphite form by causing metallic vapors to act upon the amorphous carbon at the high temperature of the electric furnace. Various metals, such as iron, silicon, titanium, aluminium, boron, or compounds thereof, may be used. The graphitization of petroleum coke by means of iron vapor is described as follows: Into a long electric furnace, with electrode terminals at the two ends, petroleum coke is charged, broken so that its particles vary in size from a powder to lumps, three or four inches in diameter, so that the lumps are fully and completely imbedded in the powder. Through this mixture iron oxide is scattered, or roughly mixed with it, in the proportion of five pounds of iron oxide to 100 pounds of coke. To start the operation, carbon rods are extended through the charge, in contact with each other, and with the terminals at two ends, so as to form a continuous conductor. The charge is covered with an air-excluding layer of sand and powdered carbon, in proper proportion to form carbide of silicon. With a furnace of 30 feet in length, 14 inches in width, and 18 inches deep, a current of 300 amperes at 200 volts is suitable. The current quickly increases as the result of the reduction of the resistance of the carbon rods and of the surrounding coke with rise of temperature. During the operation of the furnace, the oxide of iron is first reduced to the metallic state, whereupon with further rise of temperature the iron is volatilized and more or less fills the entire furnace, thus coming into intimate contact with the whole charge. The coke is thereby converted into soft graphite. (12,964, June 1, 1909.)

Aluminium Silicates Treatment.—Alf Sinding-Larsen proposes to treat silicates of aluminium, such as feldspath, common clay, kaolin, in an electric furnace in contact with iron (scrap iron or iron ore) and coke. The electric furnace process may be combined with an electrolytic process. The result of the treatment is the formation of a layer of fused ferrosilicon at the bottom and slag containing aluminium oxide at the top. (927,758, July 13, 1909.)

Boron as Reducing Agent for the Production of Metals or Alloys.—Fred M. Becket proposes boron, ferroboron, or borides as reducing agent for the production of chromium, tungsten, molybdenum, vanadium and their alloys. For instance, to produce low-carbon ferrochrome from chromite, use is made of the reactions $Cr_2O_3 + 2B = 2Cr + B_2O_3$ and $3FeO + 2B = 3Fe + B_2O_3$. In case a carbon boride or carbon-boron compound is employed, the proportion of boron is reduced in accordance with the carbon content, the carbon under these conditions serving also as reducing agent. The process is facilitated by the presence in the charge of a base capable of uniting with the oxide of boron produced. Most commercial chromites contain from 8 to 15 per cent. of aluminium and a similar proportion of magnesia, and to the extent of their presence these serve the purpose of a basic flux. The process is preferably carried out in an electric furnace. (924,130, June 8, 1909. Assigned to Electro Metallurgical Co.)

Alloy for Resistors.—John T. H. Dempster patents a silicon-tellurium alloy for use as a resistance material for heating units, etc. The alloy may contain from 1 to 15 per cent. of tellurium. The use of 5 per cent. of tellurium increases the resistance of silicon from three to five times without making it brittle or introducing any other undesirable physical changes in the cast material. (923,152, June 1, 1909. Assigned to General Electric Co.)

Ozonizer.—Alexander Vosmaer patents an ozonizer, consisting, as shown in Fig. 2, of a tubular casing 1, with perforated top and bottom plates 2 and 3. Extending between them are a number of rods 4, the middle portions of which constitute the electrodes 5, with serrated surfaces or made up of wire netting or gauze. These electrodes are arranged concentrically within the tubular dielectris 6, supported by means of upper and lower caps 7, by the rods 4. Arranged around and concentric with the dielectrics 6 are tubular electrodes 8 of perfo-

rated metal or gauze, supported by a perforated partition 9. The air to be ozonized is passed through the casing from 10 to 11, and passes both outside and inside of the dielectrics and through the field of electric discharges. The tubular form of the electrode units insures a large surface, so that there is a

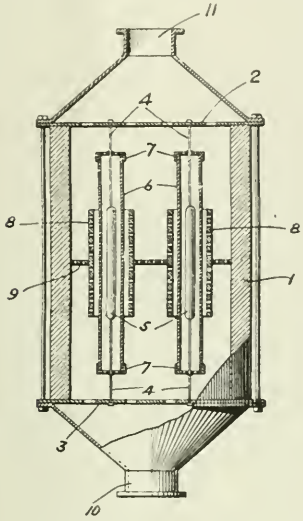


FIG. 2.—OZONIZER.

relatively low current density per square unit, which tends to protect the dielectric from undue strain. (919,403, April 27, 1909; assigned to U. S. Water Improvement Company, of Philadelphia.)

Manufacture of Insulating Compound Fiber.—Several interesting problems of physical chemistry, involved in the manufacture of the insulating compound, commonly known in the electrical art as "fiber," are discussed in two recent patents of Dr. W. R. Whitney, chief of the Research Laboratory of the General Electric Company. The problems have broadly to do with the purification of porous materials. In the manufacture of "fiber" it is customary to treat sheets of cellulose by passing them through a strong solution of zinc chloride, after which the sheets are piled one on another and compressed into a homogeneous mass. The zinc chloride is then removed by washing. This washing is usually performed in several distinct steps by suspending the porous mass in different zinc chloride solutions of diminishing concentration until pure water is reached, for it has been found that if the material is placed directly in pure water the osmotic pressure of the salt in the pores of the mass will draw in an excess of water and form water blisters. These blisters cause splits in the final product and are the cause of the great losses in material which sometimes occur even when extreme care is taken to prevent their formation by gradual rather than by rapid washing. The thicker the sheet to be produced the greater the difficulty due to osmotic pressure, and consequently the time and care necessary to remove the zinc chloride, the complete removal of which is imperative. On this account, six weeks of washing by gradual treatment with more and more dilute solutions of the chloride is necessary for sheets of an inch or more in thickness, thus greatly increasing the cost of material when made in thick masses.

The osmotic pressure of a solution depends on its concentration. The rate of diffusion of a salt from a concentrated solution to a dilute solution depends on the concentration differences of the two solutions, with respect to that particular salt alone, and not with respect to other soluble substances which may be carried in one or the other solvents. These factors Whitney makes use of by utilizing, as a solvent for the zinc chloride, a solution which is "isotonic" with respect to the zinc chloride solution to be removed. By isotonic is meant a solution having such a concentration that it will have the same osmotic pressure as the zinc chloride to be removed. Thus, for example, a solution of glycerine, or glucose in water, may be used to wash the fiber mass and thereby remove the zinc chloride employed in the chemical preparation of the mass. In this way the concentration of zinc chloride in the wash water is kept low, and consequently its rate of diffusion from the mass into the wash water is not very high. The osmotic pressure of the washing solution being high, and of any desired predetermined value, does not allow the formation of water blisters in the fiber. The solution of glycerine or glucose in the wash water is not in any way detrimental to the product. To further facilitate the removal of the zinc chloride, Whitney employs electrolytic action, yielding zinc and chlorine at suitable cathodes and anodes, respectively. By a suitable addition of alkali and acid in dilute form to neutralize the products liberated at the electrodes and to preserve the isotonic condition of the washing liquid, the process practically amounts to the replacement of the zinc and chlorine within the fiber by the components of water, which from an electrochemical point of view are H and OH ions. (923,227 and 923,745, June 1, 1909.)

Electroplating.

Metal Foil by Electrodeposition.—In order to produce electrodeposits which can be readily removed from the cathode on which they are deposited, Harry Schmidt first "polarizes anodically" (i.e., uses as anode) the electrode which as cathode is afterward to receive the deposit. To produce metal foil in

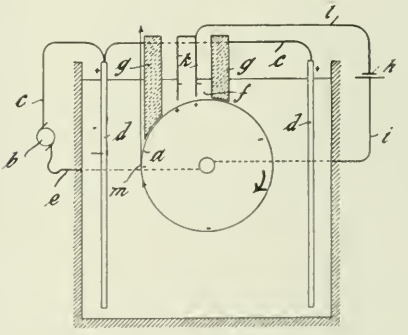


FIG. 3.—DEPOSITION OF METAL FOIL.

an endless strip, he uses the apparatus shown in Fig. 3. The metal is deposited on the revolving cylinder *a*, which is cathode, the electroplating current passing from the dynamo *b* through the wire *c* to the anodes *d*, through the solution to the cylinder *a*, and through the wire *e*, back to the dynamo *b*. This current deposits metal on the cylinder *a*. But previously the surface of the revolving cylinder has been "anodically polarized" within the space of between the partitions *g* by means of a current from the battery *h* through the wire *i* to the cylinder *a*, then to the plates *k* and through the wire *l* back to the battery *h*. If the deposited metal foil is drawn off the cylinder *a* at some point *m* before the isolated part of the bath, an endless strip of metal foil is obtained. This method can also be employed for producing extremely thin foil suitable for being ground to form bronze. A modification of the apparatus for producing an endless hollow pipe is also described. The voltage employed for the anodic polarization is 0.8 volts or less when producing thick electrodeposits, and 1.3 volts when producing nickel foil of the thickness of tin foil, and about 3 volts while producing a deposit suitable for being ground to form bronze. (916,033, March 23, 1909.)

Electroplating Hollow Tubes.—To electroplate the inside of hollow tubes, E. Friedheim uses anode rods within them, and provides insulating sleeves for the anodes to prevent short-circuiting between anodes and cathodes. Several forms of insulating sleeves in form of a perforated insulated sheathing or of an insulating ribbon, wound around the anode, are described. (915, 840, March 23, 1909.)

Plating Rack.—D. B. Moyer patents a hanger for the suspension of articles to be electroplated. It consists of a metallic rod, protected against metal deposition by a wood sheathing, with detachable metallic branch rods, projecting laterally through the wood sheathing and not protected, from which the articles to be plated are suspended. (915,786, March 23, 1909.)

Iron and Steel.

Basic Bessemer Process.—Josy Flohr patents the following process for cooling and dephosphorizing the molten charge in a basic Bessemer converter: Pure burnt lime, slaked with water, is pressed into bricks and only dried to such an extent that the calcium hydroxide remains as such in an undecomposed state. Toward the end of the decarburizing period, or later, the converter is tilted and the calcium hydrate briquets are introduced into the bath. The process is then completed by again blowing in air. (920,560, May 4, 1909.)

Tool Steel.—Jesse M. Darke patents a tool steel suitable for cutting tools for lathes, planers, milling machines, etc. It is chemically characterized by the presence of about 13.5 per cent. tungsten (or about the percentage now found in the so-called high-speed steels), by the presence of about 3 per cent. manganese (not more than 3.25 per cent. nor less than 2 per cent.), by low carbon content (less than 0.5 per cent.), and by low chromium content (less than 0.5 per cent.). (919,544, April 27, 1909; assigned to General Electric Company.)

Electric Steel Refining.—With respect to a recent proposition of O. Thallner, of Bismarckhütte, mentioned on page 326 of our July issue, another patent of the same inventor is interesting. At Bismarckhütte electric steel refining is carried out by the Heroult process. According to Thallner's present patent the steel refined in an electric furnace with basic lining is passed into a crucible with an acid fire-proof lining. The steel previously refined in the electric furnace is allowed to stand in the crucible for a few hours so that the remainder of the slag which has not been separated by the reaction in the furnace settles on the top of the material in the crucible. Thallner has found that such a separation cannot be produced by prolonged treatment in the electric furnace, for the reason that the disturbance of the material between the electrodes is too violent to permit of the settling of the finely mixed particles of the slag which have not been removed by the reaction and which are distributed through the molten mass like the constituents in an emulsion. When allowed to remain in the crucible, however, the influence of the basic-lined electric furnace is counterbalanced as in the crucible silicon, is taken up and thereby the steel receives the typical properties of what is usually called crucible steel, and the process also permits of the production of alloys of iron in a very controllable manner, or the addition of modifying agents, as is usual in the crucible process. These additions can only be added with great difficulty in an electric furnace, as the temperature conditions are so variable that when additions usual in the crucible process are made totally different results as regards grain and structure of the metal and other physical qualities are obtained. These difficulties can be avoided according to the present process by passing the steel into the crucible before the addition of the modifying constituents. Likewise the carbonizing of the steel can take place in the crucible by means of suitable known carbonizing agents. (919, 493, April 27, 1909.)

Induction Furnace.—Otto Frick, whose induction furnace has been reported to be employed at the Krupp works in Essen, patents the construction, shown in Fig. 4. The primary winding 3 surrounds one arm of the rectangular transformer iron core; the same arm is surrounded by the annular hearth 2. "The other limbs, 4*b*, 4*c* and 4*d*, of the core do not closely include the primary and secondary circuits of the transformer furnace, as is usual in ordinary transformers, but are at such distance from them that the leakage fields, when the furnace is working, do not in an essential degree pass through the iron. The limbs 4*b* and 4*c* are not in contact with the primary winding, but have a free space between them and the winding. Also between the limbs 4*c* and 4*d* and the secondary circuit is a

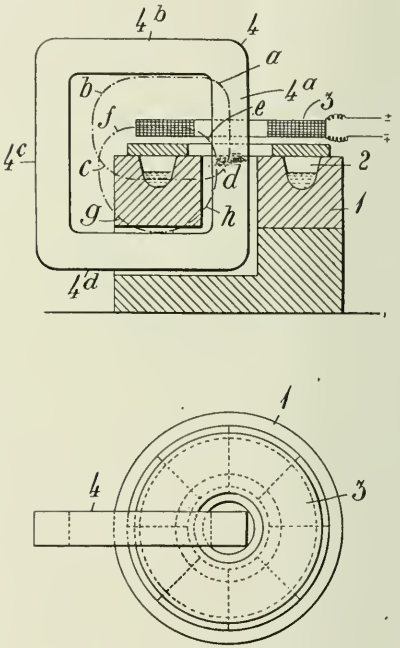


FIG. 4.—INDUCTION FURNACE.

space that is greater than the space between the primary and secondary circuits. The dotted lines *a*, *b*, *c*, *d* in the upper diagram represent the limits of the primary leakage field, the dotted lines *e*, *f*, *g*, *h*, the limits of the secondary leakage field. An essential feature of the invention lies in the possibility of designing the cross-sectional form of the primary winding without interfering with the diameter of the secondary member, while at the same time iron is avoided in the leakage fields. By the combination of a primary winding facing a horizontal side of the hearth and a magnetic core of the form above described it is possible to use a primary coil of a flat-disk form, such a coil having a high magnetic resistance in the leakage field around it, whereby the self-induction of the furnace is reduced." (917,040, April 6, 1909.)

Copper.

Precipitation of Copper and Silver by Thionates or Thionites of Iron.—G. C. Westby, of Murray, Utah, proposes to precipitate copper and silver from their solutions by means of thionites or thionates of iron. The solution for prescription can be cheaply prepared by treating slags, ferrous sulphide, iron or oxidized ores with sulphurous acids or sulphur smoke scrubbing liquor. In preparing the solution from slag—which is the cheapest method—the material is blown into wool or otherwise finely divided. It is then charged into barrels and a solution of sulphur dioxide or smoke scrubbing liquor is added, or

sulphur smoke is caused to impinge on the material in the presence of water. In order to hasten the solution, the mixture may be agitated. After allowing the suspended matter to settle, the supernatant liquor is drawn off, and is added in a suitable receptacle to the solution of the metal to be precipitated, and the mixed solution is heated to any required temperature. (923, 916, June 8, 1909.)

Zinc-Copper Alloy.—The object of a patent of T. Elliott is to produce a zinc-copper alloy at a temperature much below the melting point of copper. He first melts the zinc, then adds the copper to the molten zinc, and then raises the temperature to the melting point of the alloy, which is less than the melting point of copper and also less than the boiling point of zinc. "For example, assuming the melting point of zinc to be 412 deg. C. and its boiling point 1040 deg. C., and the melting point of copper to be 1090 deg. C. and the melting point of the alloy to be produced 973 deg. C., it will be noted that when the copper is placed in the molten zinc at 412 deg. C. it begins to dissolve, but even so, the temperature is raised to 973 deg. C. or thereabout, which is less than the melting point of the copper, and also less than the boiling point of the zinc, yet is high enough to produce an alloy having a perfectly homogeneous structure." In carrying out the process the metal is covered with charcoal or borax. (927,843, July 13, 1909.)

Zinc.

Zinc Distillation Furnace.—Woolsey McA. Johnson has devised the furnace, shown in Fig. 5, in vertical section and horizontal cross-section along line 22, for zinc ore reduction, and in general for the treatment of any charge yielding a volatile product. It has massive fire-brick walls 1, encased in a metal sheath. The walls 1 enclose a chamber 5, in which is

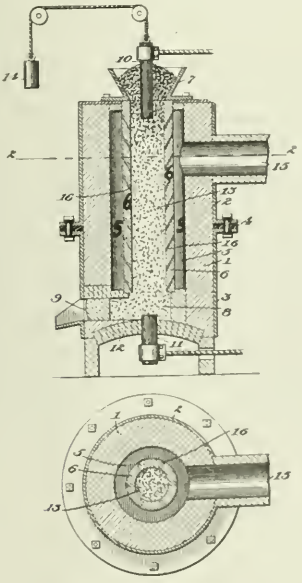


FIG. 5.—ZINC DISTILLATION FURNACE

concentrically disposed a permeable tubular casing 6, constituting the reaction chamber of the furnace and constructed of highly refractory non-conducting material. The casing 6 communicates at its upper end with a hopper 7 and at its lower end with a chamber 8, to which access is afforded for the removal of residue by the door 9. At the top and bottom electrodes 10 and 11 are provided. The charge of zinc ore and carbon is passed from the hopper into the central chamber 13 of the furnace. The zinc vapor distills off through the upwardly inclined apertures 16 in the walls 6 into the outer ring-formed conduit 5 and then into a suitable condenser. The construction permits an easy escape of the zinc vapor from the reduction zone; the conduit 5 serves at the same time as a heat-insulator and reduces the heat loss to the outside. Instead of employing solid walls 6 with aperture 16, it is possible to use a porous casing, which is readily prepared by incorporating 10 to 20 per cent. by volume of charcoal with a refractory fireclay and afterward eliminating the same by firing. (920,473, May 4, 1909.)

Zinc Dust.—Sherard Cowper-Coles makes zinc dust or "tultz powder" by depositing zinc upon a rotating iron disk under such conditions as will insure deposition in spongy form. An electrolyte of hot or cold caustic soda solution is used with anodes of iron or an alloy of zinc and iron known as hard zinc. The current density is several hundred amperes per square foot. The zinc sponge is removed from the iron disk by means of a scraper. "The electrolyte may be regenerated in a separate chamber or vessel, and an economical form of zinc is either scrap zinc or what is known as hard spelter obtained from the baths of hot galvanizing works. The bars or slabs of zinc are suspended in the baths or tanks and the zinc deposited upon the iron electrode. In the process of regeneration a considerable amount of electric current is generated if the hard zinc is coupled to an electro-negative metal such as lead, and this may be used for a variety of purposes. For example, it can be utilized for the recovery of zinc and copper from impure zinc-copper alloys, as a low voltage and current density are sufficient for this purpose. A convenient form of electrolyte for this object is sulfuric acid, the impure brass to be treated being placed in this electrolyte and in connection with the positive pole of the electric generator composed of the zinc couples above referred to. The copper is deposited at low current density on suitable cathodes, and the zinc sulphate which is formed may be evaporated down to crystals or the zinc may be deposited by electrolysis." Zinc dust prepared by the above method is especially suitable for the process of "sherardizing" (our Vol. V, p. 187; Vol. VI, p. 189). The zinc dust must be dried in a reducing atmosphere to prevent the formation of too much zinc oxide. (723,411, June 1.)

Mercury Ammeter.

The problem of measuring large alternating currents with any degree of precision with any of the various types of instruments which have been on the market is, from a technical standpoint, a difficult one. All who have had any experience in this class of work agree that there is need for a standardization instrument, which can be inserted directly into an alternating-current circuit carrying 500 amp and over which will measure this current to the same degree of precision that small currents may be measured.

As a suggestion toward an instrument which would meet these conditions, in 1907, in a paper entitled "Some Newly Observed Manifestations of Forces in the Interior of an Electric Conductor," published in the *Physical Review*, June, 1907, Dr. E. F. Northrup proposed an alternating-current ammeter based on the forces he described. At that time a crude instrument was shown. Since that time, the Leeds & Northrup Company have steadily perfected this instrument until it has reached a point where, practically speaking, the only limit to accuracy of the instrument is the accuracy to which the ultimate unit of current is known. A paper descriptive of the developed instrument, its theory and tests of accuracy, was read by Dr. Northrup at the meeting of the American Electrochemical Society at Niagara Falls, Canada, May 6 to 8, 1909.

The Leeds & Northrup Company state that their new instrument, which they designate the "mercury ammeter," is intended for use as a primary standard instrument for large currents, either alternating or direct. It is intended for the calibration

...instruments, and for use in the determination of ... ratios. However, its very small resistance, together with the absence of inductance in the instrument, open to it a number of uses in the alternating-current field which are closed to instruments possessing impedance.

The mercury ammeter is intended for use in the measurement of currents of 200 amp and over. The lowest practical range in the present type of instrument has a full scale corresponding to 500 amp and this instrument on 200 amp may be read to 1.5 per cent accuracy. The standard length of the scale is about 22 in.

Very exhaustive tests have been conducted on a number of these instruments using the potentiometer with direct current and Kelvin balances with alternating current as calibrating instruments. In brief, it has been shown that this mercury ammeter may be read over three-quarters of the scale to an accuracy of 0.1 per cent, this accuracy being totally independent of the kind of current being measured; that is, the same instrument is equally accurate upon direct current and alternating currents of any wave form, and any frequency up to 133 cycles. The scale follows the "square law," and the reading is in terms of the mean square value of the current. Also, the tests have shown that the temperature coefficient of the instrument is negligible when it is used as a standard.

A great deal of care was exercised in the determination of the effects of external currents upon the indications of the instrument. The results showed that appreciable errors resulted only when conductors, carrying heavy currents, were placed directly over or directly under the instrument in contact with the base. For instance, when a conductor carrying a current equal to the full scale reading of the meter (200 amp) was placed over the base of the instrument parallel to its length, and in immediate contact with it, a 0.3 per cent error resulted. This was the maximum error observed, and when the distance between the conductor and the instrument was increased, the error rapidly diminished.

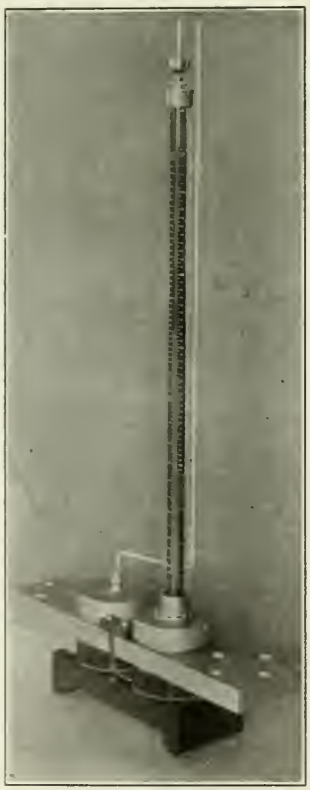


FIG. 1.—MERCURY AMMETER.

With regard to the constancy of the mercury ammeter, an instrument built in 1907, embodying all of the essentials of the present instrument, at the present date, shows absolutely no perceptible change.

It has a period of about five seconds; that is, it will pass from ... full-scale reading in five seconds. For facility of reading, ... meter is built to be just short of "dead beat."

We present herewith a photograph of this instrument, which is of great simplicity of construction, with a complete absence of springs, valves, and all other mechanisms.

The operation of the instrument is quite simple. The copper terminals of the instrument are bolted into the circuit without any regard for polarities. The "zero" of the instrument is roughly adjusted by leveling, and finally by turning the thumb-nut at the top of tube. The current is then thrown on, and the colored liquid will flow up to a point in the scale corresponding to the current flowing. Current is then read directly from the scale.

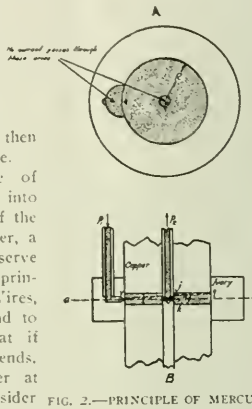


FIG. 2.—PRINCIPLE OF MERCURY AMMETER.

It is beyond the scope of the present article to go into the details of the theory of the mercury ammeter. However, a very simple analogy will serve to make clear the essential principle of the instrument. Wires, when carrying current, tend to attract each other so that if they were fastened at the ends, they would swing together at their center. We can consider a liquid conductor as being made up of an infinite number of elemental conductors, parallel to the directions of flow of the current. The right-hand and left-hand sections of the mercury ammeter are very similar in construction, and consist of copper plates alternating with insulating plates, having various holes drilled in each side and closed reservoirs for mercury.

If the current enters through one copper leaf, in order to get to the next copper leaf of the cell it must pass through the mercury-filled space within the ivory ring. The principle is indicated in Fig. 2, where *A* is a cross-section on the line *a b* of *B*. When an electric current passes from the copper leaf *j* to *k*, it must pass through the intermediate disk of mercury. In doing so, it causes the mercury to tend to flow away from the edges and "bank up" at the center. The force causing this action is exactly the same force that causes solid conductors carrying current to tend to attract each other. This attraction toward the center causes mercury to flow down the tube p_1 and up the tube p_2, until this driving force is just balanced by the force due to the difference in hydrostatic head between the levels of the liquids in the two tubes p_3 and p_4.

It is an interesting fact that the ammeter consumes about one watt per inch of scale reading, regardless of the amount of current to which 1 in. of scale corresponds.

The calibration of the instrument is dependent only upon the number and diameter of the disks or cells, the density of the liquid which serves as an indicator and the force of gravity. The liquid is not exposed to evaporation and, due to the fact that the instrument involves only hydrostatic heads, the effect of variations in the diameter of the index tube is eliminated, as is also the possibility of error due to "drainage effects." Within wide limits the calibration is also independent of temperature changes.

This instrument involves the application of new principles in instrument design. Its development necessitated the satisfactory solution of a large number of incidental structural difficulties, of a type totally different from those normally arising in electrical measuring instruments. The accuracy of this completed instrument, its simplicity, together with entire absence of all corrections, make it well-nigh ideal considered solely as an instrument, while the fact that it performs a function for which no other tool is at all feasible justifies the belief that the mercury ammeter is destined to occupy a position alongside of the

potentiometer and the dynamometer as a high precision standardizing instrument.

Girod Electric Steel Furnace.

Since the note in our July issue, page 323, was published, three other works have signed contracts for the installation of the Girod electric steel furnace. The corrected list is now as follows:

S. A. E., Procédés Paul Girod, Ugine, France, four furnaces.
Oehler & Company, Aarau, Switzerland, one furnace.
Cockerill & Company, Seraing, Belgium, one furnace.
Stotz & Company, Stuttgart, Germany, one furnace.
Marrel Frères, Rive de Gier, France, one furnace.
Danner & Company, Judenburg, Austria, one furnace.
Gutehoffnungshutte, Oberhausen, Germany, one furnace.
Stahlwerk Becker, Crefeld, Germany, three furnaces.
Poldihutte, Alt-Kladno, Austria, one furnace.
Ternitzer Stahlwerk, Ternitz, one furnace.
Diosgyor Staahlwerk, Diosgyor, Hungary, one furnace.
Making 16 in all, with capacities up to 12 tons.

The American representatives of the Girod furnace and process, Messrs. C. W. Leavitt & Company, of New York, state that an American works has also just signed a contract to install a Girod furnace.

Rail Handling Magnets at Gary.

During the past few years the advantages of lifting magnets in large-scale practice have been generally recognized and many new applications of magnets have been made. The Electric Controller & Manufacturing Company, of Cleveland, Ohio, as the pioneer in this field, has designed and applied new types of magnets to new kinds of service.

An exceedingly interesting application requiring a new design of magnet is the handling of the entire output at the immense rail mill of the United States Steel Corporation's plant at Gary, Ind. This mill is of the most modern design in every respect, and electric power has been used throughout, even to the driving of the rolls by 6000-hp motors. The handling of the finished rail by electric power through the use of lifting magnets was, therefore, a logical conclusion, providing a successful magnet could be made.

FIG. 1.—ELECTROMAGNET LIFTING 60-FT. RAILS.

The handling of the rail output by means of magnets was particularly desirable from the following considerations:

First—Sufficient labor alone could be dispensed with to make the application commercially attractive.

Second—A very large saving in time of handling would be effected.

Third—Very much less timber spacing material was necessary in loading.

Fourth—There being no possibility of bending the rail when loading by magnets, loss on this score would be eliminated.

While it is desirable from the standpoint of the rail mills and railroads to ship rails in locked sections, yet this is an arrangement of rails which is particularly difficult to handle with a magnet.

The difficulty arises from the fact that the top layer of the rails practically short-circuits the magnetic field and none but a very powerful and carefully designed magnet would have sufficient strength to penetrate the top layer of rails and lift the bottom layer.

The magnets, which were furnished by the Electric Controller & Manufacturing Company, have been very successful and have lifted not only locked sections of 33-ft. rails, but have also successfully lifted locked sections of 60-ft. rails with an aggregate load of 15 tons.

FIG. 2.—ELECTROMAGNET HANDLING 33-FT. RAILS.

Fig. 1 shows an electromagnet of the Electric Controller & Manufacturing Company handling a locked section of 60-ft. rails at the rail mill of the Indiana Steel Company, at Gary, Ind., the lifts being from 12 tons to 15 tons. Fig. 2 shows, at the same plant, the handling of a locked section of 33-ft. rails, the lifts being from 10 tons to 12 tons.

With equal success electromagnets are employed at Gary for handling the raw material. In the open hearth stockyards the cranes employed for unloading the pig iron and scrap from the railway cars are equipped with electromagnets. When it is desired to release a load of pig iron, current is sent through the electromagnet winding in the reverse direction; in this manner it is stated that the load is released within half a second, while without the reverse current 12 seconds are required for releasing the load.

Electric Laboratory Furnace Exhibit.

During the summer meeting of the American Chemical Society, held in Detroit, June 30 to July 2, a special exhibit of electric furnaces was prepared for the visiting chemists at the new plant of Hoskins Manufacturing Company.

The three types of Hoskins furnaces in different forms and standard sizes were shown in actual operation. A complete connected train of apparatus, including Hoskins combustion tube furnace run on standard voltage, for determination of the carbon content of steel, was displayed. A crucible furnace of standard voltage type, in connection with a Hoskins pyrometer, was shown in use for obtaining the "recalescent" points of steel specimens. Crucible and tube furnaces of heavy wire, low-voltage type, were shown in operation at a temperature of

1200 deg. C. (2192 deg. Fahr.). These furnaces were controlled by small step-down transformers operating from the standard voltage circuit. Under working conditions of melting special nickel alloys, to be used in the production of resistance wire, the Hoskins type FC furnace was shown. This furnace produces temperatures as high as 2000 deg. C. (3632 deg. Fahr.) by means of a carbon plate resistance unit worked at low voltage.

In connection with these furnaces, a complete installation of Hoskins pyrometers was exhibited. Included in this was shown an illuminated dial meter, connected through a selective switch with several thermo-couples placed in the various furnaces on display. By moving the switch, instant indication of the temperature of any of the furnaces was shown on the meter. Separate instruments, including the well-known Hoskins portable pyrometer, were also shown.

Of particular interest were the new types of laboratory hot plates exhibited. These were in two styles, those with uniform heat distribution, and those in which the heating unit was located in the center of the plate, both producing temperatures up to 350 deg. C. (662 deg. Fahr.).

An inspection followed of the manufacture of these products. This included the resistance-wire production department, the shops assembling departments, and testing laboratories. Eighty members of the society visited the plant.

Notes.

A Record Shipment of Large Graphite Electrodes.—While the International Acheson Graphite Company of Niagara Falls may always be expected to be in position to meet the extended and varied requirements of old and new customers in all parts of the world, its facilities were recently tested in a special particularly important case, and were not found wanting. Between 1 and 2 o'clock on the afternoon of Friday, July 2, a telegraphic order, calling for the shipment of a carload of electrodes, 8 in. x 48 in., by express, was received. Their works and an express company were immediately notified. At 5 p. m. an express car was delivered on the track in front of their products building. At 5:30 p. m. a locomotive on the Niagara Junction Railroad was pulling away with the loaded car for delivery to the Michigan Central Railway. It left Niagara Falls about 6 p. m., Buffalo about 8 p. m., and very early on Saturday morning the electrodes were delivered to the consignee in Chicago, Ill. The regular shipments of the day were not interrupted, there was no overtime, and the consignees were made happy by the prompt shipment. The value of the service to the customer is more apparent when it is known that if the business judgment of the Acheson Graphite Company had not been such as to have these very large electrodes in stock, a delay of from 10 to 12 weeks would have resulted. Regular and prospective customers should always anticipate their wants as much as possible, for, ordinarily, the time period specified is consumed in getting the carbons and graphitizing them. In connection with this we may point out that there are now many signs which denote a rapid and important association or merger of electrochemical and metallurgical interests. The above shipment by express of a carload of electrodes has since been duplicated, indicating the eagerness with which engineers are engaged in applying new processes to manufacture. Confidential reports received by Electrochemical and Metallurgical Industry are to the effect that there is a most pleasing renewal of vigor in many processes using electrodes, a fact which may be accepted as meaning that the great interest taken in the convention at Niagara Falls was but the forerunner of a disposition on the part of many to promote in every way possible the advancement of electrochemical and metallurgical interests.

Mr. F. A. J. Fitz Gerald, of Fitz Gerald & Bennie Laboratories, Niagara Falls, N. Y., has returned from Europe, where he went to consult with certain large German and French interests with regard to the construction of electrical furnaces for a new metallurgical (non-ferrous) process which, they believe, will be applied on a large scale in Europe.

Mr. **W. S. Osborne**, of the Osborne Engineering-Manufacturing Company, has made connections with the Griscom-Spencer Company, who have arranged to manufacture and sell all the machinery covered by his patents. This includes the Osborne Pneumatic Blast Separators, Osborne Vacuum Separators, Dust Collectors, Hydrating Machinery, Osborne Gas Washing and Smoke Consuming Apparatus, and all of the machinery covered by the above mentioned patents.

Lomb Memorial.—In the presence of the 1,800 employees of the Bausch & Lomb Optical Company, a bronze and marble memorial tablet in honor of its founder, the late Henry Lomb, was unveiled on July 8 in the factory of the company in Rochester. The inscription on the tablet includes the last public utterance by Captain Lomb, which was spoken on June 5, 1908, to the directors of the Rochester Public Health Association, in reply to their request for advice. The words were: "Think of others first, yourselves afterward." The entire inscription is as follows: "Think of others first, yourselves afterward. Henry Lomb, 1828-1908. This tablet is given in testimony of our love for our true friend and counselor, who by his noble deeds and good life gave to us a rare example of simple greatness to study and emulate. By unanimous vote of the employees of the Bausch & Lomb Optical Co." In behalf of the company the memorial tablet was accepted by the president, Mr. John J. Bausch, who, jointly with Henry Lomb, founded the company more than 50 years ago.

Recording Instruments for Blast Furnace Plants.—The Bristol Company, of Waterbury, Conn., have recently issued Bulletin 103, which describes some of Bristol's recording instruments especially adapted for blast furnaces. They include the Bristol recording pressure gauges, recording thermometers, electric time recorders and the Wm. H. Bristol indicating and recording electric pyrometers.

Electric Steel Induction Furnace.—According to a recent notice in the London *Times* Supplement, the Council of Sheffield University has decided to purchase a Kjellin induction furnace for experimental purposes in the applied science department. The decision was formed principally on the advice of Sir Joseph Jones, vice-chairman of that department, who has also given £500 toward the cost of the furnace. Sir Joseph stated that he had tested and analyzed electrically-made steel, sold in Germany at £31 per ton, and had taken Sheffield-made steel at equal prices, and he had come to the conclusion that they in Sheffield were being outpaced. Sir Joseph added that he was satisfied from his own business knowledge that the time would come when the electrical process would rank among the methods of making steel in Sheffield.

Fixation of Atmospheric Nitrogen and Production of Oxygen.—In our last number we gave a description of the Cyanamide Works at Odda, Norway, and of the Linde plant for separating nitrogen and oxygen from air. It may not be commonly known that a Linde plant has been in successful operation in this country for nearly two years, at Buffalo, being employed in the production of oxygen. The Linde Air Products Company are now not only duplicating the capacity of their already extensive Buffalo plant, but are building a second factory in Chicago which will be in operation very shortly. Other plants are to be constructed next year. At the present time between fifty million and sixty million cubic feet of oxygen are being produced annually by these Linde plants.

The Vanadium Alloys Company's plant at Telluride, Col., is the subject of an illustrated article in *The Daily Journal* of Telluride of June 28. The works as originally built in 1905 were described in our Vol. IV. page 105. From the description and illustrations in the Telluride *Daily Journal* it appears, however, that the plant has been considerably enlarged during the past few years, and that quite a material further enlargement in capacity and equipment is contemplated for the near future. Mr. A. W. Brand, the president, and Mr. Tyndal Rynard, the

general manager of the company, are to be congratulated on the success of their enterprise—the pioneer works of the vanadium industry in this country. Mr. A. M. Wilson is the head chemist of the works. The product is vanadate of iron, containing 60 per cent. vanadic acid.

More Koppers By-product Coke Ovens for United States Steel Corporation.—The 280 Koppers by-product coke ovens in the Joliet plant of the Illinois Steel Company have proven so successful that the U. S. Steel Corporation has now decided to adopt the same system for the Gary, Ind., plant, where 8 batteries, each of 70 ovens, are first to be installed. The construction of the Koppers oven has been slightly simplified in a few details for the Gary plant. Each oven will be charged with 13 tons and will yield 11 tons of coke. The total daily output of coke is estimated as 6,500 tons, besides 50,000,000 cubic feet of gas, with a calorific value of 500 Brit. thermal units per cu. ft., and 80 tons of ammonium sulphate.

Oil Refining in Burma.—A recent consular report states that on account of the rapid development of the oil industry in Burma, a company has been registered in Rangoon for the manufacture of sulphuric acid for local oil refining. The company is capitalized at $160,000, which has been largely oversubscribed by local investors, including oil companies. If the project is successful, various other products will be manufactured, such as vegetable dyes, fertilizers and other articles, utilizing the alkali earth deposits of Burma. At present sulphuric acid is high, as the charges for freight, insurance, and packing add heavily to the cost price. It is now imported from Great Britain alone, last year's importation amounting to 2080 short tons, valued at $119,766, or $57.60 per ton. The duty is 5 per cent ad valorem, which, with the cost of freight, insurance, and packing of the imported article is expected to afford ample protection for the local product.

The Scientific Materials Co., of Pittsburgh, Pa., has issued a new catalog of Laboratory-Supplies which is the largest and most complete ever published in the United States. The book, which is bound in flexible cloth, contains 540 pages and describes over 3000 different forms of apparatus used in laboratory work, every one of which is listed in all the different sizes ordinarily used. The large number of new and improved forms of apparatus which they manufacture shows that they have been keeping pace with the advance in laboratory methods. The general arrangement and the manner in which the details have been carried out make it very easy for anyone to turn to the apparatus required and select the one best suited for the purpose intended, as everything is listed under its natural alphabetical classification and where two or more classifications suggest themselves they are cross-indexed. The 2000 different illustrations give directly a concrete and exact idea of the material with a minimum amount of descriptive matter. All ambiguous terms have been eliminated and where two or more items of the same name, but of different construction, are listed, the differences are brought out in heavy type.

Digest of U. S. Patents

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, Notional Union Building, Washington, D. C.

Electric Furnaces (Continued).

611,142, Sept. 20, 1898, R. Pignotti, F. Lori, S. Regnoli, M. Besso, and M. Pantaleoni, of Rome, Italy.

Arc type. This furnace, especially designed for the production of calcium carbide comprises a substantially air-tight chamber having side walls and an apertured roof of poorly conductive material (charcoal and kaolin), and a laterally removable carbon bottom resting on a conducting plate and having a central opening, closed by a movable carbon plug, through which opening the material is discharged into a wheeled receptacle. Extending above the furnace chamber is a shell, through the upper wall of which depends a conducting rod on the end of which is secured, by a screw thread-cement connection, the upper carbon electrode. The generated gases pass into this shell and escape through a pipe, and are burned, to preheat the charge, about a receiving hopper discharging by a screw-conveyer and laterally inclined passage into the furnace chamber. As the reactions take place in an air-tight chamber combustion of generated gases and waste of electrodes are prevented.

612,943, Oct. 25, 1898, Louis Bresson, of Lyons, France.

Arc type. To be used for producing calcium carbide. The furnace consists of an ovoid-shaped steel or iron shell to which is bolted a truncated-cone shaped fire-clay-lined iron cover. Rotatably mounted on the cover is a tightly closed hopper, through which passes a chimney for waste gases, which thus preheat the charge. The bottom of the hopper and the cover have registering openings, so that rotation of the hopper permits the charge to flow into the furnace. Secured to the furnace shell are rotatably mounted trunnion-disks having axial openings through which project the carbon electrodes movable in sockets, each mounted on two rods, mounted with an interconnected parallel motion lever-system by which the position of the arc can be changed without varying it's length. One of each pair of rods is longitudinally extensible, by operation of a motor in shunt across the arc to regulate the same. Furnace can be emptied by tipping without interrupting the current.

614,930, Nov. 29, 1898, George D. Burton, of Boston, Mass.

Resistance type. Designed for reduction of refractory ores of gold, silver, etc., containing sulphur, arsenic, etc. The cylindrical furnace body rests on piers, provided with shoulders to sustain the bottom when lowered. The top has a covered charging opening and a valved pipe with interior baffles for conveying vapors to a metal-lined liquid-containing receptacle.

The electrodes may be composed of perforated disks of an alloy of Cu, Sb and Sn, and are carried by valved metal tubes, passing through top and bottom to which the conductors are clamped. The charge, consisting of ore, cabon, and flux (common salt, chlorate of potash, or borax), is placed between the electrodes. As the current heats the charge, moisture is allowed to escape through upper electrode; roasting heat then drives off sulphur, etc., and further rise of heat successively melts metals which pass through holes in lower electrode and tap hole in bottom of furnace. As bulk diminishes, one electrode is movable to maintain contact and other electrode is rotatable to stir up the ore in the furnace.

616,906, Jan. 3, 1899, James A. Deuther, of Boston, Mass.

Arc type. Designed for production of calcium carbide. The lower electrode is a carbon plate mounted on wheels running on tracks carried by a wheeled truck. The counter-balanced square upper electrode is raised and lowered by a rack and pinion connected to operating mechanism carried on a platform, above which are four hoppers having depending tubes for feeding powdered material downwardly along each side of the upper electrode, to which is clamped a framework carrying a casing within which are mounted flat-bladed fans for delivering material into the arc. A series of telescopic casings resting on the lower electrode and of greater area than the upper electrode is raised by it as the reduction proceeds. The unconsumed material between the arc and casings protects the latter from the heat. The lower electrode is automatically reciprocated under the upper electrode. This reciprocating mechanism, together with the hopper feed, the fan delivering mechanism, and the mechanism for raising the upper electrode, are driven at the proper relative rates, by suitably arranged gearing from a common power shaft. The upper electrode can also be operated by hand.

NEW BOOKS.

Ostwald, Wilhelm and Morse, Harry W. Elementary modern chemistry. 312 pages, illustrated. Cloth, $1. Boston: Ginn.

Gotfrey, Hollis. Elementary chemistry. 470 pages, illustrated. Cloth, $1.10. New York: Longmans, Green & Co.

Segerblom, Wilhelm. Tables of properties of over 1500 common inorganic substances. 154 pages. Cloth, $3. Exeter, N. H.: Exeter Book Publishing Co.

Marks, Lionel S. and David, Harvey N. Tables and diagrams of the thermal properties of saturated and superheated steam. 100 pages. Cloth, $1 net. New York: Longmans, Green & Co.

Rise and Progress of the British Explosives Industry. Published under the auspices of the International Congress of Applied Chemistry by its Explosives Section. 432 pages, illustrated. Cloth, $5.25 net. New York: Macmillan Co.

Cushman, Allerton Seward. The preservation of iron and steel. 40 pages. Paper. Washington, D. C.: United States Office of the Superintendent of Documents.

Ville, Georges. Artificial manures: their chemical selection and scientific application to agriculture: tr. and ed. by Sir W. Crookes. New ed. rev. by Sir W. Crookes and J. Percival. 385 pages, illustrated. Cloth, $3 net. New York: Longmans, Green & Co.

Workshop Receipts for Manufacturers and Scientific Amateurs. New rev. edition, Vol. 1, Acetylene lighting-drying. 540 pages, illustrated. $1.50 net. New York: Spon & Chamberlain.

Lewis, Myron H. Waterproofing: an engineering problem; reprinted from a paper read before the Municipal Engineers of the city of New York, Nov. 25, 1908. 52 pages, illustrated. 50 cents. New York: Engineering News Publishing Co.

Koester, Frank. Hydro-electric developments and engineering: a practical and theoretical treatise on the development, design, construction, equipment and operation of complete hydro-electric power transmission plants. 475 pages, illustrated. Cloth, $4. New York: D. Van Nostrand Co.

Harrett, A. H. Hydraulic tables and diagrams for practical engineers. 48 pages. Cloth, $5. New York: Longmans, Green & Co.

BOOK REVIEWS.

The Journal of the Institute of Metals. Vol. I, 1909. Edited by G. Shaw Scott, M. Sc., Secretary. 310 pages. London: The Institute of Metals (Caxton House, Westminster, S. W.). Price one guinea.

The Institute of Metals was founded in 1908 with not less than 413 "original members." The first meeting was held in Birmingham on Nov. 11 and 12, 1908, the first annual general meeting in London on Jan. 19 and 20, 1909. Sir W. H. White is the president, Mr. G. Shaw Scott the secretary.

Vol. I of the *Journal* contains the proceedings and the papers presented at the two meetings in Birmingham and London. Sir William White, in his presidential address, discussed the origin and the object of the Institute of Metals as "a specialized society which should deal with the metallurgy and manufacture of *non-ferrous* metals and their alloys, on lines parallel to those which have yielded remarkable results in regard to iron and its alloys since the Iron and Steel Institute was founded in 1869."

The papers published in this volume are "Some points of interest concerning copper and copper alloys," by J. T. Milton; "The mechanism of annealing in the case of certain copper alloys," by G. D. Bencough and O. F. Hudson (emphasizing the value of equilibrium diagrams for practical metallurgists); on "aluminium and some of its uses," by J. T. W. Echevarri (in steel metallurgy; aluminium castings; sheet aluminium; aluminium powder for paints; electric conductors of aluminium); "Notes on phosphor-bronze," by A. Philip; "Metallographic investigations of alloys," by Walter Rosenhain; "Intermetallic compounds," by Cecil H. Desch; on the "Plant used in the manufacture of tubes," by W. H. A. Robertson; on "the relation between science and practice and its bearing on the utility of the Institute of Metals," by Sir Gerard A. Muntz (discussing especially the interrelation between the work of the manufacturer, the scientist, and the engineer; insisting among other things on the necessity of bringing science down to the manufacturers' level).

It is worth emphasizing the fact that while the papers themselves cover 128 pages, the discussions (though in smaller print) cover not less than 118 pages.

Finally we may quote the concluding passages of Sir Gerard A. Muntz' paper: "Knowledge is power, but power often runs to waste, and the knowledge of non-ferrous metals has hitherto run much to waste: chiefly through jealous fear of teaching a trade opponent something, whereas he has probably long since discovered it for himself. Each individual has some cherished bit of knowledge, some trade secret which he hoards carefully. Perhaps by sharing it with others he might impart useful information; but by an open discussion and interchange he would, almost for certain, learn a dozen things in exchange for the one given away.

"General increase of knowledge would give improved practice, most likely a larger use of the materials in which a manufacturer is interested. Each would give a little and receive a hundredfold in exchange. No man knows everything; even the cleverest has lots to learn yet; and after all, with equal opportunities of knowledge, it will still be the best man who will best apply that knowledge; if members have courage and confidence in themselves, they need not hesitate to exchange their knowledge with that of their colleagues or even their adversaries. There are enormous potentialities for usefulness in this Institute, and if only it can break down those barriers of narrow-minded selfishness, and gather all the scattered items of science and practice together, there can be no doubt as to the usefulness and successful future of the Institute of Metals."

Investigation of the Peat Bog and Peat Industry of Canada During the Season 1908-9. By Erik Nystrom and S. A. Anrep. (Bulletin No. 1, Canada Department of Mines, Mines Branch.) 25 pages and 6 large maps. Ottawa: Government Printing Bureau.

Besides the renowned pioneer work on the electrometallurgy of iron and steel, the Department of Mines, Ottawa, Ontario, under its director, Dr. Eugene Haanel, is paying great attention to another problem of hardly less importance—the possibilities of peat.

A year ago the Department of Mines issued an excellent treatise by E. Nystrom on "Peat and Lignite; Their Manufacture and Uses in Europe." This first report, which gave a conservative summary of what has been actually accomplished with peat in Europe, was of great general interest and remains the best reference book of its kind.

This report is now followed by a bulletin entitled "The Investigation of the Peat Bogs and Peat Industry of Canada During the Season of 1908-9." It includes six large scale maps of the following peat bogs: Mer Bleue, near Ottawa; Alfred peat bog, about 40 miles from Ottawa; Welland peat bog, about six miles north of Welland; Newington bog, on the New York & Ottawa Railway and about 40 miles from Ottawa; Perth bog, a mile and a half from Perth; Victoria Road bog, about a mile from Victoria Road station on the Midland division of the Grand Trunk Railway.

The bulletin contains a descriptive report of each bog, showing the location, area and structure, and giving an estimate of the available supply of peat fuel with records of analyses, calorific values, etc., and should be of particular interest to those engaged in, or connected with, the development of Canadian peat sources.

A fuel-testing plant is now being erected at Ottawa, in which the value of peat for the production of power gas will be demonstrated, and the Department of Mines proposes to carry on a very thorough investigation of this subject.

Copies of the above Bulletin and Report on Peat may be had on application to Dr. Eugene Haanel, Director of Mines, Ottawa.

Electrochemical and Metallurgical Industry

VOL. VII. NEW YORK, SEPTEMBER, 1909 No. 9

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH.D.....*President*
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Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, SEPTEMBER, 1909.

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Electrode Troubles and Electrode Losses.

The demand for furnace electrodes has been aptly called a barometer of electrometallurgical activity. From the present indications of this barometer the near future of the electrometallurgical industry looks exceedingly bright. On the other hand, electrodes represent just at present the chief trouble of electric furnace designers and operators. With the increase in the size of furnaces, there has arisen, with comparative suddenness, a demand for very large electrodes, but the baking of the largest sizes of amorphous carbon electrodes, so as to procure the same strength and durability as for the smaller sizes, seems still to involve some difficulties. In one very prominent case recourse has recently been had to graphite electrodes, which, while more expensive, are strong and durable and easily machined, there being no waste of electrode ends, as a new electrode is easily screwed into the end of an old one. After all, the first requisite is mechanical strength of the electrode; as described at the end of Mr. Hansen's interesting article in our present issue, the breakage of electrodes may cause very considerable trouble. In one case we know of, the trouble was enough to make an opening for the induction furnace. But as Mr. Hansen points out, there is nothing inherent in the nature of carbon that makes perfect electrodes impossible; and it is safe to say that the manufacture of large and perfect amorphous carbon electrodes in this country is only a question of time. Then there is the consumption of the electrodes by oxidation; this depends, to a considerable extent, at least, on the conditions of operation. Mr. Hansen's article gives some interesting data on this item. Finally, we have to consider the heat losses through the electrodes, which may form in many cases an important item in the heat balance sheet of the furnace.

* * *

Valuable experimental results on the heat losses through the electrodes were given by Mr. Hansen in former papers, while the results of a theoretical investigation of the same subject are given in a very interesting article by Mr. Hering in this issue. While Mr. Hering's article gives only general results, but not the methods and formulas of his analysis, we are glad to say that the latter will be given in full in two articles which Mr. Hering has promised us for our next two issues. For this reason we refrain for the present from a discussion of this subject, but wish to emphasize that in our opinion a purely theoretical investigation of such matters is exceedingly valuable and its importance should not be underrated. Even if such an analysis can be only approximate, it will give certain indications as to the lines along which experimental work should be carried out. Progress is generally made along such lines that we first make abstractions and establish a law which contains certain constants; then we make experiments and establish the discrepancies of the facts from our law and the way how our "constants" change. This gives a new law, and so on. The excellent work done by Mr. Hering and Mr. Hansen along theoretical and experimental lines will give us exact rules on

the dimensioning of electrodes. We are evidently now quickly approaching the time when electric furnace design will be as exact a science as dynamo-electric machinery design has been for many years.

* * *

Mr Hering's article refers to the dimensioning of electrodes for continuous operation of the furnace. It will not be out of place to call attention to the fact that it may be necessary to employ other rules for the dimensioning of electrodes in such cases where a furnace is often started and stopped. Here the time element of starting becomes important. At present it seems that for quickly starting a furnace, the induction furnace has distinct advantages. Concerning the speed with which energy can be pumped into an induction furnace, interesting data were given in an article by Mr. FitzGerald on page 10 of our January issue.

Special Steels.

Professor Burgess' invention, made a few years ago, of a practical method of producing a very pure, carbon-free iron by electrolytic refining, has opened great possibilities for the industry of special steels. Our whole old metallurgy of steel has been restricted essentially to carbon-steels. Starting with electrolytic iron, Professor Burgess and his co-operators at the University of Wisconsin, have been able to prepare non-carbon steels containing various elements, and with assistance from the Carnegie Institution they have carried out an extensive study of the mechanical, electrical and magnetic properties of these steels. This is virtually a virgin field, with unlimited possibilities. We are glad to announce that the results so far obtained by Professor Burgess will be published in a series of articles in this journal. The first article will be found in this issue. The results obtained by Messrs. Burgess and Aston on the influence of arsenic and tin upon the magnetic properties of iron are both interesting and suggestive.

Refractories.

Since Peclet made his determinations of the heat conductivities of various materials, very little has been done by other experimenters to supply us with exact figures of the heat conductivities of the principal materials employed in furnace construction. This is really a remarkable state of affairs, in view of the absolute necessity of using these constants in the heat balance sheet of metallurgical furnaces. Further progress in metallurgy will depend essentially on hearty co-operation between theory and practice, by basing all practical designs of apparatus and processes on exact principles. But in order to do that, nothing is more needed than exact figures of the important physical constants of the various materials used in practice. For this reason we believe that the article by Wologdine and Queneau, the first part of which is published in this issue, forms a very important contribution to general metallurgy, in spite of its obvious shortcomings with respect to the temperature range treated. The part published in this issue deals with the conductivities of a large number of refractory materials, while the concluding installment, to be published in our next issue, will deal with their porosity and gas permeability. Our universities could do nothing more useful for chemical and metallurgical engineering than to establish researches along similar lines.

The Swing of the Pendulum.

Several analogies are conceivable between the laws of mathematical physics and those of political economy. One of the most general phenomena of the physical world is that of periodic vibrations—we see them in sound, in electromagnetism and, in fact, anywhere. A similar cyclic process is seen in trade. There is a period of quiescence, then a betterment of business, increased confidence, a new era of prosperity, excitement, over-speculation, a panic, liquidation, retrenchment, finally a period of quiescence again. This is the cycle of industry. We have seen the long swing of the pendulum and we have seen its short swing. Some writers are even quantitative in their reading of the past. Thus, they say: The country had the great panics of 1833, 1853, 1873, and 1893, and of 1837, 1857, 1877 and 1907 showing a periodicity of 20 years except when trade skips a beat, like the heart of an invalid, and the secondary panics having a period of 10 years. Whatever degree of accuracy be ascribed to this theory, it is undoubtedly true that business alternates between extreme industrial energizing and extreme industrial restriction in periods of 10 years or even multiples thereof, and that the years ending in '3 or in '7 mark usually the crisis.

* * *

Hard times are basically caused by the integrated extravagance of the nation. When everybody is making money and seeing his income increase, the temptation to spend is great. When much is spent on luxuries, which do not bring any great return in satisfaction, the demand for all labor and supplies is increased. As the old law of supply and demand works 24 hours a day, 365 days a year, the prices for all commodities and for all classes of labor increase with this increased demand. As the prices of all commodities are increased, the purchasing power or economic effectiveness of a dollar is decreased. As its effectiveness is decreased, its real earning power is decreased. On the other hand, due to the demand for capital, the interest rates are increased in the gradually increasing commercial activity. Hence the entrepreneur class, who borrow money to make it earn more than the rates of interest, are each year basically in a less and less favorable condition, although apparently they are each year of expanding business in a more and more favorable condition. Finally, the state of affairs grows worse until business must react, because the marginal profit for the entrepreneur has reached zero as its limit. For the interest rates have risen and the depreciated dollar will earn less than the interest asked on the ideal-national average. Finally, a panic is started by some act like a "run" on a financial institution. Then a period of acute forced liquidation starts in the financial world and is transmitted to the manufacturing and distributing worlds. Outside conditions affect the cycle of prosperity and adversity both in its period and in its amplitude. For instance, the increase in the supply of gold increases the reserves and sustains the inflation. Fortuitous events, like earthquakes, great fires or wars between nations, "consume and destroy" and unhealthily stimulate trade. Unwise and paternalistic legislation destroys credit rapidly. The application of the principles and facts of science to everyday life and all industry increase the usufruct of the dollar and healthily stimulate trade.

* * *

But, after all, the average human mind changes very little

and it is especially prone to exaggerate both its hopes and its fears. And these errors are in the main the causes of commercial alternations. If each person would regulate his expenditures with a perfection of economic foresight, production and consumption would increase with the expansion of civilization at a small uniform rate and the practical effect would be a calm and steady progress. In short, the commercial impulses would be "commutated" and we would have a "direct current" and not an "alternating current." We have seen one bad panic and its subsequent period of liquidation, commercial house-cleaning and national economizing. The country after several years of high living is having a couple of years of saner living. The panic of 1907 gathered slowly, but its start was precipitated like almost every other serious panic by an incident that profoundly excited the fears of the capitalistic class. When fears as to the safety of the institution of credit are generated they proceed to the distributing and manufacturing classes. Each company, and, broadly speaking, each individual is both a producer and a consumer. If each consumer curtails his purchases even by a small amount he affects some other producer. And as each concern finds the market for its goods restricted, it starts in to retrench in its purchases. The same things occur with each individual. In this way the numberless chains of producer-consumer consumer-producer transmit the shock, which proceeds like a nervous chill through the commercial body. Finally the recuperative forces begin to have their effect. Labor, which was once dictatorial and inefficient, becomes now willing and efficient. The promoter, and especially the reckless promoter, has his schemes tested most carefully for their merits. Free capital piles up in the money centers and thus interest rates fall to such a rate that the margin for the entrepreneur, which previously to the panic had shrunk to zero, is now at a maximum. Improved processes and new machinery of certain and demonstrated value are installed. Finally, industry revives, at first slowly, then at an increasing rate. The circuits of producer-consumer and consumer-producer send out pulsations of nervous vigor and optimism. In fact, the nation's business no longer suffers from nervous prostration. Whereas the mouse would not gnaw the rope, the rope would not hang the man, and so on through the long series of causations till the pig refused to jump over the stile, the mouse starts to bite vigorously the rope, and the rope to hang the man, etc., till the stick begins to beat the dog and the dog to bite the little white pig, and the latter, with his old feminine owner, both get safely home. In an exactly analogous manner do the wheels of industry start turning each other.

* * *

All panics resemble each other somewhat, and each individual panic resembles a certain other panic specifically. Thus, the panic of 1893 resembled the panic of 1873 in the fact that legislation affecting the currency system in the United States did much to precipitate both. The panic of 1907 resembled even more strikingly the panic of 1857. As the last report of the New York Chamber of Commerce points out, there were in the years preceding both 1857 and 1907 the same immense increase in gold production and the same consequent inflation of prices, and the same increase in interest rates. There had also been the same extension of credits and the same waste of capital in unproductive works. Likewise, there had been the same great outlay in gigantic enterprises, the returns from which were delayed for years. Prior to 1857 had been the Crimean war. Prior to 1907, the Russia-Japanese war. The report also points the recovery as follows: "The year 1858 had been distinguished in the annals of commerce as one of the most important of the nineteenth century; distinguished alike for great fluctuation in market values, for a rapid recovery from the effects of the revulsion of the year 1857, and for the development of commercial enterprise at home and abroad." In 1858 "the process of recovery from depression involved a great falling off in the imports and the liberation of a large amount of capital from active employment. The money market became, therefore, flooded with money, and this reduced the rate of interest to a very low point." Precisely the same course has been seen in the year 1908. Imports decreased nearly $200,000,000 for the entire country, and over $100,000,000 for the port of New York. At the close of the year 1908 the money markets of the world were filled to overflowing with money seeking investment in sound securities. Whereas in January, 1908, the Bank of England's discount rate was 7 per cent, it had fallen at the close of the year to 2½ per cent.

* * *

The year 1908 shows the further analogy that the recovery started strongly because in both 1857 and 1907 the business of the country was inherently sound. Great enterprises, like the St. Paul extension to the Pacific Coast, the Gary Steel Works in Indiana, were well planned. Their final execution was at a reduced cost because of better conditions in the labor market and lower cost of supplies. The large copper reduction works in Utah and Nevada working on "monzonite" low-grade ores were designed for a maximum efficiency over a long period of years. All this vast aggregate of capital was tied up in 1907 in an unproductive form in the above-mentioned and similar enterprises. It is now giving handsome returns on the original investment. The year 1909 is showing, for many reasons, a healthy recovery over 1908. This is clearly indicated by the returns from the railroads, and especially by the increased iron production. Tariff agitation and the usual uncertainty about crops are brakes on the upward trend. Undoubtedly the greatest bear cards on the world's industrial horizon are the ill-advised socialistic legislation by the British House of Commons and the rivalry of the nations in building monster battleships. On the other hand, money is plentiful and interest rates low. Our industrial enterprises are managed each year with a higher degree of financial wisdom, commercial sagacity, and technical skill. National and individual extravagance will be always prevalent in a young, growing country. The labor question we will always have with us. And it will always manifest a disturbing influence in good times when the demand for labor is great. In general business, there seems to be a settled feeling that industry should be governed by a tempered and conservative enthusiasm rather than by an unlicensed exuberance. Unfortunately when prosperity is again in full swing, many will neglect conservatism and steer for charybdis in an ultra-optimistic spirit. For the old pendulum of trade swings pretty regularly between the excess of inflation and the excess of restriction, since its swings are caused by the vagaries of the average human mind. And the human mind changes but little as the years roll along.

The Iron and Steel Market.

As regards strictly new business, August has not been as active a month in the iron and steel trade as was July, while that month had fallen below June. In the case of both July and August the new business booked exceeded expectations, these expectations having been very moderate on account of there having been such heavy buying during the second quarter and by reason of July and August being normally very quiet months in the trade.

New buying by the railroads, however, has been very good, with the important exceptions of fabricated material and rails. Orders for steel cars and for locomotives have been increasing, while orders for car and track repair material have been very good. The consumption of tie plates this year is particularly good. Recently one of the several producers of tie plates, the Illinois Steel Company, reported that it had booked this year orders for 40,000 tons, while an order for 15,000 tons from the Harriman lines was pending. The present appearance is that the answer to the requirement for a better track support is the treated tie and tie plate, rather than the all-steel tie. The latter has of late made little progress into favor.

While it is improbable that the railroads will soon reach the rate of iron and steel consumption shown in 1906 and 1907, improvement is clearly being made. Outside the railroads, some lines of consumption have already shown a better tonnage than in either 1906 and 1907, and it is quite possible that within a twelvemonth this increase will be sufficient to bring the total tonnage to a new record rate, without the railroads doing as well as they did at their best.

The rail mills have opened their books for 1910 deliveries, and have made reservations of a considerable tonnage. In the spring there were some prospects that for 1910 the standard price of rails would be reduced, the prospects of tonnage for 1909 not having furnished any incentive for making an earlier reduction. The question of making any reduction has been finally dismissed, partly by reason of the general improvement in trade and partly through matters arising from the desire of the railroads for rails of better quality. The negotiating now is as to quality at the standard price, and as to extras to be charged for still better quality. The strategic position of the railroads is improved by the change, since it is easier to obtain concessions along the lines of better quality than along lines of a reduction in the base price.

Specifications on contracts for finished steel made in the second quarter have continued excellent, and mill operations have continued to increase.

Pig iron production has continued to increase, July showing a rate of 25,000,000 tons a year of coke, anthracite and charcoal, while August shows a still better rate. An increase in midsummer is altogether exceptional, as the output of a given furnace invariably decreases on account of the humidity. The increase in total production has occurred through the blowing-in of many additional furnaces, and prospects are that furnaces now operating will make a much larger output in October. It is not possible that October will make a new rate in pig iron production for the country, the previous record having been 28,000,000 tons a year, made in October, 1907.

The United States Steel Corporation, in July, made a new record for pig iron production, although not employing its full capacity, which has been largely increased since 1907. The independents ran practically full, and the fact that a new record for the country was not made was due largely to the fact that the merchant furnaces have not increased output as rapidly as the steel works furnaces. The product of the steel works furnaces has been going immediately into consumption and stocks at steel works have been reduced.

The labor disturbances which started in July have not all been settled. The Pressed Steel Car Company's strike is being stubbornly continued by the men, while the Amalgamated Association members have not yielded to the open-shop requirements of the American Sheet & Tin Plate Company. The company, however, has made some little progress toward breaking the deadlock, and is operating some of the mills in question with non-union labor. As to tin plate, the dull season has been reached and the requirements are not much heavier than the output of the 90 mills of the company, which have been regularly non-union.

Pig Iron.

Pig iron advanced slightly in the Central West early in August, while throughout the month the Eastern and Southern markets have showed an advancing tendency. In the East it is computed that foundry iron is within about 50 cents of the importing point, but experience in past movements has shown that the attainment of the theoretical balance does not invite imports because consumers do not care to change their brands except for a decided advantage in price. In 1907 there were times when imported iron, on dock, Philadelphia, was quoted $2 a ton under domestic iron. The tendency, however, is to arrest the advance in the East, while there are some indications that in the Central West the advance has already been arrested by furnace conditions. Additional furnaces are being blown in, while there are still some stocks of importance, and many consumers appear to be fully covered for the year. One evidence of this is that considerable inquiry has appeared for first quarter and first half delivery. In the fore part of August Bessemer pig iron advanced sharply to $16, valley, or $16.90, Pittsburgh, and sales were made, about 15,000 tons each, to the Republic Iron & Steel Company and the Youngstown Sheet & Tube Company. The market stands firm at this price. Basic and No. 2 foundry advanced to $15.25, valley, or $16.15, Pittsburgh, the market being firm at that price, with a tendency to ask high prices for fourth quarter or next year's delivery. Forge stands at $14.25, valley, and malleable at $15.50, valley.

Billets and Sheet Bars.

Billets and sheet bars have become very scarce, billets being quoted at an advance of a dollar a ton from July, at $24 for Bessemer and $25 to $26 for open-hearth, while sheet bars are $25.50 for random lengths and $26 for cut bars. These prices are at mill, Pittsburgh, plus full freight to destination. The advance in the general market has been greater than appears from a comparison of Pittsburgh prices, since formerly a portion of the freight from Pittsburgh was conceded in naming delivered prices. Forging billets are $1 higher at Pittsburgh, being quotable at $28. Rods are $31, Pittsburgh, since the $2 advance at the close of July.

Finished Materials.

Finished steel products have continued their advancing tendency. Steel bars have gradually advanced until the minimum is $1.35, Pittsburgh, an advance of $2 a ton in a month. Iron bars have moved upward, partly in sympathy with steel bars and partly on account of the stronger scrap market, and are quotable at $1.50, Pittsburgh. Plates and shapes have definitely advanced a dollar a ton, being quotable at $1.40 to $1.45, small orders regularly commanding the higher figure. By the advance of July 26 all wire products were advanced $2 a net ton, making nails $1.80. There is still a great deal of business being filled at the old price of $1.60, which ruled May 1 to May 15. A fair amount of business was taken at the advance of May 15, while very little tonnage has been booked at the advanced prices of July 28. It is definitely understood that while the leading interest will make no advance in tin plate for this year's delivery, it will not book orders for next year at less than $3.55, or 15 cents advance over the price ruling since last March. The market is quotable as follows, f.o.b., Pittsburgh:

Steel bars, $1.35, base.
Iron bars, $1.50, base.
Plates, $1.40 to $1.45.
Shapes, $1.40 to $1.45.

Standard rails, $28 for Bessemer and $30 for open-hearth, f.o.b. mill; light rails, 25 lb. to 45 lb., $26.50 to $27.50.

Sheets, 28 gauge, black, $2.20; galvanized, $3.25.

Tin plates, $3.40 for 100-lb. cokes.

Merchant steel pipe, ¼ in. to 6 in., inclusive, nominally 80 per cent off in "jobbers' carloads"; actual inside price, 81 and 5 off.

Plain wire, $1.60, base; wire nails, $1.80, base; painted barb wire, $1.80; galvanized barb wire, $2.10.

Electrometallurgy in Mexico.

The Mexican Steel & Chemical Company, organized under the laws of the Republic of Mexico, has been formed for the purpose of manufacturing different varieties of steel, calcium carbide and certain chemicals in the Republic.

The company will use the Héroult type of electric furnace for the manufacture of tool and drill steel, shoes and dies, forgings and steel castings, and it will also make light steel rails, 14 lb., 16 lb., 18 lb. and 20 lb. The rail plant will have a capacity of 20,000 tons of rails per annum to begin with, and the capacity of the electric steel furnace will be 16 tons to 20 tons per day of steel ingots.

These ingots will be worked up under the hammer into the different forms of tool and drill steel, shoes and dies, car axles, etc.

The company has also ordered, and is now constructing a plant for the manufacture of calcium carbide at the City of Mexico, using a continuous type of furnace.

The plant will have a capacity of from 3000 tons to 5000 tons of carbide per year, which will be sold in the Republic for purposes of acetylene lighting. Electric current will be furnished by the Mexican Light & Power Company, and will be taken from its mains at about 20,000 volts pressure.

Both the carbide furnace and the steel furnace will be of the single-phase type.

The company also expects to manufacture certain chemicals in a large way later on.

The carbide furnace should be in operation in about six months, and the steel plant some months later.

The company has purchased a tract of land of about 30 acres within the city limits of Mexico, where the work of construction is now going on.

Mr. Robert Turnbull, St. Catharines, Ont., Canada, acting for Dr. Héroult, will design and construct the steel furnace, while the carbide furnace will be designed and constructed by Mr. Charles Bingham, of 11 Queen Victoria Street, London.

Mr. J. T. Morrow, 25 Broad Street, New York City, is the managing director of the company.

Calcium Carbide Suits.

Judgment has just been rendered in two suits of the Union Carbide Co. versus the American Carbide Co. before the United States Circuit Court, Northern District of New York.

The first suit was based on the product patent 541,138 of Thomas L. Willson of June 18, 1895. The Union Carbide Co., as owner of this patent, charged the American Carbide Co. with infringement. Mr. Louis C. Raegener was counsel for the complainant, Messrs. Kernan & Kernan, with Mr Charles Neavs and Mr. Willis Fowler were counsel for the defendant. The judgment is in favor of the defendant; the patent is upheld as valid, but no infringement is found

The decision is rendered by Judge Ray. The principal claim of the patent refers to "a new product crystalline calcium carbide, existing as masses of aggregated crystals." We take from Judge Ray's decision the following extracts "It seems to me plain on the face of the patent in connection with the file wrappers of his previous applications, that during the prior proceedings in the Patent Office, resulting in the final rejection of the claim for calcium carbide broadly, Willson had become informed that crystalline calcium carbide existed and was known prior to the date of his invention, and that after the rejection of his claims, he made up his mind that he had discovered, produced and invented 'a new form' of crystalline calcium carbide, one having a peculiar iridescence and existing as masses of aggregated crystals . . ."

Reference is made to an article by Moissan, of November, 1899, and Judge Ray says: "It is apparent from this and other publications and evidence that calcium carbide had been produced by the electric current in a suitable furnace as early as 1899, by others."

It is then pointed out that there are two forms of crystalline calcium carbide, first that existing in the form of crystal aggregates, or what is the same thing as aggregated crystals, and this may be in masses, and second, that existing in the form of crystalline aggregates. Judge Ray says: "I am of the opinion and hold under the weight of evidence that crystalline calcium carbide as Willson understod it, exists in at least two forms—not referring to the amorphous condition which is not crystalline in any sense, but the opposite." Messrs. Whitlock, Doremus, and Crocker, witnesses for the defendant, are quoted in this respect.

"I think the patent valid for what it claims, viz., crystalline calcium carbide existing as masses of aggregated crystals. I think this is a new form of calcium carbide produced by the use of lime in the presence of carbon heated, etc., in a socalled electric arc furnace, and that it is a form of calcium carbide which discloses such progress in the art as to make the patent valid. I think that by the process used by Willson he discovered a new and better form of crystalline calcium carbide, a new subdivision of it." . . .

"It is not sufficient for the complainant to show that defendant produces the commercial or chemical equivalent of complainant's crystalline calcium carbide existing as masses of aggregated crystals. The patent is for a particular form, a new form, and that form must be produced by defendant to constitute infringement."

Prof. Doremus is quoted as having examined defendant's calcium carbide and found it not to be crystalline calcium carbide, existing as masses of aggregate crystals, within the definition of the latter

Judge Ray finally concludes: "It was necessary for complainant to show, by admission, or otherwise, that defendant's product is calcium carbide; that it is crystalline and that its crystallinity consists in the fact that it, the carbide, exists as masses of aggregated crystals. To determine whether or not it so exists we must turn to the dictionaries and scientific works and writings of the time when this discovery was made and ascertain what the words used in the claim then meant, if they meant anything. This is what defendant's experts have done and this is what the Court has endeavored to do. Infringement must be proved by the complainant by a fair preponderance of evidence Satisfied that infringement of this narrow claim is not made out, there will be a decree dismissing the bill with costs."

* * *

The second suit was based on the process patent of Willson, 563,527, of July 7, 1896. Messrs. Dickerson, Brown, Raegener and Matty, with S. L. Moody, were counsel for the Union Carbide Co. as complainant, while Messrs. Kernan & Kernan with Charles Neavs and Willis Fowler represented the American Carbide Co. as defendant. As this patent had expired since suit was brought, the decree could have been no injunction, but an accounting only. For this reason this suit was of less importance. But it is interesting as an endeavor is made to give a legal distinction between an arc and a resistance furnace In the principal claim of this patent Willson speaks of "subjecting mingled lime of a carbonaceous deoxodising agent to the heat of an electric arc in an electric furnace . . ." Willson's patent refers therefore to an arc furnace.

Judge Ray reaches the following conclusions: "I think the

evidence established 1, that the material used by the defendant in its texture or some of it, acts as a conductor and is not a gaseous vapor; 2, that some of this material offering resistance and being of low conductivity becomes intensely heated to incandescence; 3, that in addition, because of the imperfect action of this conducting material, innumerable small arcs are formed which aid in giving the heat; 4, that there is no single arc in the defendant's process, except at the very beginning and when the current is being established, and that this is very soon extinguished when the material is fed in filling the space between the electrodes and extending up around the carbon pencils, forming the upper electrode; 5, that the reducing of the material fed in and intended to be reduced is done mainly, but not wholly, by incandescence, for the reasons stated. Finally, I think it shown by the preponderance of evidence that defendants' furnace, on the whole, acts on the incandescent principle, and not on the arc principle, and must be termed an incandescence furnace, and, therefore, is not within or covered by the limited claim in issue of the patent in suit. It follows that the defendant does not infringe, and the bill of complaint must be dismissed with costs."

* * *

The above decisions, rendered by the United States Circuit Court of the Northern District of New York, are the first decisions rendered in the calcium carbide litigation in this country.

It is understood that the Union Carbide Company has appealed to the Court of Appeals.

German Foundrymen's Association.

A German Foundrymen's Association (Verein Deutscher Giessereifachlente) has just been formed in Berlin for the furtherance of foundry practice and science. The offices of the association are at 60 Sybel Strasse, Charlottenburg.

Institute of Metals.

During the first year of its existence the membership of the (British) Institute of Metals has increased from 200 to well over 500. The first volume of the *Journal* of the institute has been issued, and was reviewed in our August issue, page 374.

The autumn meeting of the Institute will be held in Manchester on Oct. 14 and 15.

We learn that when Sir William White, K.C.B., F.R.S., retires from the presidency of the Institute of Metals at the end of the present year, it is almost certain that Sir Gerard Muntz, Bart., will be nominated to the vacant office. The vacancy in the vice-presidency caused by the recent death of Mr. Norman Cookson, of Newcastle-on Tyne, has been filled by the council, which, at a recent meeting, unanimously elected Dr. H. C. H. Carpenter, of Manchester.

Faraday Society.

The forty-fifth ordinary meeting of the (British) Faraday Society was held in London on June 15, Dr. N. T. M. Wilsmore occupying the chair.

Mr. E. R. Taylor, of Penn Yan, N. Y., presented a paper on "the national and international **conservation of water for power.**" In substance it was the same as his paper before the International Congress for Applied Chemistry, abstracted in our July issue.

In the discussion which followed, Mr. Walter Reid pointed out that the conservation of water power over large areas might be very difficult of accomplishment in England, where the value of land was so high, and where there was a large number of cities very close together. Moreover, the question of scenery, which was a national possession, had frequently to be taken into consideration. The Government had, however, recently promised, through the president of the Local Government Board, to take action with regard to the conservation of all British rivers, each of which was to be placed under the control of one central authority.

Mr. W. Murray Morrison showed how nothing but good had followed the development of the power schemes at Foyers and Loch Leven, now the centers of a flourishing industry and population. There were many such possible centers of power, especially in Scotland. Water-power was one of the most formidable weapons with which a nation had to fight the modern war of industry.

Dr. H. Born emphasized the importance of bringing home to the nation the value of the small water-power.

The chairman remarked on the way in which the land was entirely utilized in Germany, where 20 per cent of the land was forest, and no part, as far as he knew, was given over to waste.

Mr. W. Fielding then read a paper on "the formation of silicon sulphide in the **desulphurization of iron.**" This paper was published in our last issue, page 347.

In the discussion which followed, Prof. A. K. Huntington thought it more probable that what was sublimed was a silico-sulphide of iron. He believed that oxy-sulphides of metals were formed more often than is generally supposed.

Mr. F. E. Pollard controverted the author's assumption that the sulphur exists in combination with the iron. He considered that sulphur exists almost entirely in combination with the manganese. The chairman said that silicon sulphide was not the indefinite substance the author imagined; three compounds—SiS_2 (white), SiS (yellow), and SiOS—had been isolated.

Then followed two papers by Mr. Charles A. Keller and Mr. Gustave Gin on the electrometallurgy of steel. They cover, in substance, the same field as their papers read before the American Electrochemical Society at the Niagara meeting, and abstracted in our June issue.

Production of Copper and Lead in the United States in 1908.

From two advance statements of the production of copper and lead in the United States in 1908, compiled by B. S. Butler and C. E. Siebenthal, respectively, and issued by the U. S. Geological Survey, we gather the following data:

The production of copper in the United States in 1908 was 942,570,721 lbs. This is the largest production ever made, exceeding that of 1906 by 24,765,039 lbs. and that of 1907 by 73,574,230 lbs., or 8.4 per cent. Among the States Arizona is first with 289,523,267 lbs., Montana second with 252,503,651 lbs., Michigan third with 222,289,584 lbs., and Utah fourth with 71,370,370 lbs.

The production of refined new copper of domestic origin in 1908 was 875,849,129 lbs., an increase of 91,577,702 lbs., or 11.6 per cent. over 1907. The total output of refined copper (exclusive of domestic scrap, etc.) by domestic refineries in 1908 was 1,094,700,123 lbs.

The production of refined copper in pounds in 1907 and 1908 is tabulated in the following table:

	1907		1908	
	Domestic origin.	Foreign origin.	Domestic origin.	Foreign origin.
Electrolytic	502,326,608	245,062,814	656,179,349	218,716,268
Lake	178,534,141	.....	195,503,099	.....
Casting	13,410,678	3,182,006	24,166,681	134,726
Total	784,271,427	248,244,820	875,849,129	218,850,994
Total output, domestic refineries	1,032,516,247		1,094,700,123	

The 1908 figures for domestic electrolytic include 26,785,485 lbs. lake copper which were refined electrolytically; those for 1907 contains 34,917,988 lbs. lake copper.

In addition to this production of refined copper, 9,705,103 lbs. (of which 2,551,077 lbs. were electrolytic and 7,154,026 lbs. were casting) were recovered during the year by the regular copper-refining companies of the country from domestic scrap, drosses, etc., and returns from practically all the known refiners of sec-

ondary material indicate that 13,508,574 pounds were turned out by them as casting copper and in alloys.

The production from secondary sources in 1908 was about 23,000,000 lbs., as compared with about 60,000,000 lbs. for 1907.

The production of lead in tons of 2,000 lbs. was 310,762 tons from domestic ore in 1908 (against 365,100 tons in 1907), and 97,761 from foreign ore and foreign base bullion (against 76,849 in 1907). The grand total from all sources is, therefore, 408,523 tons of lead in 1908 (against 442,015 tons in 1907). The total production of refined primary lead was 396,433 tons in 1908, the production of antimonial lead was 13,620 tons.

American Exposition in Berlin, 1910.

The American Exposition which will be held in Berlin in May, June and July, 1910, under the patronage of Prince Henry, is intended to bring together in a magnificent Exposition Palace (much larger than Madison Square Garden, New York) a representative collection of the best that American ingenuity, skill, and experience can produce, to foster and strengthen the trade relations of this country with Germany, and to increase American exports generally.

Mr. J. Pierpont Morgan and Mr. Thomas A. Edison have joined the honorary American committee. The Hamburg-American Line and the North German Lloyd have increased their original freight reduction by from 20 per cent to 30 per cent. Arrangements have been made whereby exhibitors who do not intend to send a special representative to Berlin, can have their exhibits unpacked, installed and demonstrated for a moderate charge by a special Sales Office and Bureau of Information established in the Exposition Palace.

Mr. Max Vieweger, Hudson Terminal Building, 50 Church Street, New York, is the American manager of the Exposition.

Melting Furnace Test.

Some interesting tests of a new Reyelbec furnace, built by the Hawley Down Draft Furnace Company, of Chicago, were recently made in Detroit. Two heats were made, one of 503 lb. and the other of 504 lb., in one hour and 15 minutes each, this time including the charging of the metal.

The metal consisted of a remelt of gates and valves and yellow ingot, the entire charge running 18 per cent or 20 per cent zinc. The metal was poured into an iron ladle and the temperature of the first ladleful was 1900 deg. The temperature of the second ladleful (after the ladle had become more thoroughly warmed) was 1990 deg. The metal in the furnace had, no doubt, a temperature of over 2150 deg.

The fuel consumption was a little over 18 lb. per 100 lb. of metal, but this could have been reduced by careful handling. In the tests no attempt was made to do anything extraordinary, but simply follow regular foundry practice. The Hawley Down Draft Furnace Company states that a melt can be completed within one hour, with a coke consumption not over 15 lb. or 16 lb. of coke per 100 lb. of metal.

New York Meeting of the American Electrochemical Society.

The autumn meeting of the American Electrochemical Society will be held, as usual, in New York City.

The intention is to hold the meeting on Friday and Saturday, Oct. 29 and 30. A meeting of the board of directors is to be held on Thursday evening, Oct. 28.

It is the intention to hold sessions for the reading of papers on Friday, Oct. 29, in the morning, at the Chemists' Club, and on Saturday morning another session at Columbia University, and possibly a third professional session in the afternoon. For Friday afternoon, excursions will be arranged. There will be an informal dinner on Friday evening, and arrangements will be made for entertainment of the visitors on Saturday night.

From all indications it appears that there will be a fine program of papers, while the local New York members will certainly do anything within their power to make all the visitors feel at home, so as to make the meeting a pleasant and enjoyable affair in every respect.

Measurement of High Temperatures by Thermo-Electric Pyrometers.

A paper presented by Dr J. K. Clement, of the United States Geological Survey, at the Rochester meeting of the American Ceramic Society, gives a good resumé of some fundamental principles of the measurement of high temperatures by means of the thermo electric pyrometer.

The author first discusses the gas-thermometer, which is the standard, but not suitable for commercial use, and then takes up the use of the thermo-couple for temperature measurements. In 1830 A. Becquerel suggested the thermo-couple for the measurement of high temperatures, using a couple of platinum and palladium. In 1871 Tait introduced the platinum-iridium, and in 1886 Le Chatelier the platinum-rhodium couple. The platinum-rhodium couple is the most reliable one for high temperatures. Its range is from 300 deg. C. to 1600 deg. C. For lower temperatures, 0 deg. C. to 500 deg. C., the copper-constantan couple is available.

In the last few years a number of couples of base metal alloys have been placed on the market. Their range is limited, the upper limit varying from 1000 deg. to 1400 deg.

For the measurement of temperature two methods are in use: first, the galvanometer, and, second, the potentiometer method.

The former is by far the simpler method. It can be used by any intelligent operator and requires no special knowledge of the laws of electricity. Its sensibility is considerably less than that of the potentiometer method.

With a high-resistance galvanometer, 400 ohms, and proper precautions, the observations are reliable to about 5 deg. C. up to 1100 deg. C., and above this temperature to 10 deg. or 15 deg.

Many of the millivoltmeters now on the market, however, for use with thermo-couples, all pivoted instruments, are of low resistance, less than 5 ohms.

With such instruments the reading is dependent very largely on the resistance of the couples and leads, and since this varies with temperature and length of leads, the low-resistance instrument cannot be recommended for precision measurement.

For accurate laboratory measurements the potentiometer method is recommended. Its sensibility is 1 millivolt = 0.1 deg. C.

A third method of measuring the e.m.f. of a thermo-couple, which is capable of higher accuracy than the galvanometer method and is less cumbersome than the potentiometer method, is the current compensation method. Lindeck has designed an apparatus involving this principle.

It is advisable to calibrate thermo-couples from time to time in either of the following ways.

For comparison with a standard couple the greatest precaution should be observed to insure that both hot junctions are at the same temperature, e.g., by having the couples imbedded in a large mass of metal. A second method of calibration is by the determination of the points of fusion and ebullition of pure chemical substances, in particular metals. The points recommended by Dr. Clement are: cadmium, 322; zinc, 419; silver, 961; copper, 1084.

The values given are those of Holborn and Day, and are the ones accepted at present by the Reichsanstalt. Recently Dr. Day and Dr Clement have found somewhat lower values.

Above 1100 deg. C., nickel (1435), iron (1505), and platinum (1720) may eventually be available. Until the gas-thermometer scale above 1100 deg. has been established, it is hardly advisable to use any point above the copper-point.

It is of the greatest importance that the metals used for fixed

points of the highest purity, since the melting points are altered by the presence of impurity.

For the calibration of thermo-couples by means of fixed points two methods are in use: the wire method and the crucible method.

The former requires only a small amount of metal—less than a gram. The metal can be fused between the hot end of the two wires and the e.m.f. of the couple noted at intervals as the hot junction is gradually heated. The reading immediately before the circuit is broken gives the e.m.f. of the melting point. Also, the metal, in the form of fine wire, can be wrapped about the junction of the couple and the couple introduced into a furnace heated above the melting point. At the moment of fusion the galvanometer deflection halts momentarily.

There are several objections to this method. The metal fusing in contact with platinum wires is certain to alloy with the latter, thereby making them more readily fusible, besides altering the e.m.f. of the couple. Also, if the fusing metal is heated in the air, it is liable to oxidation and a consequent lowering of the melting point.

The crucible method is free from most of these sources of error. Holborn and Day used crucibles of porcelain and graphite of about 300 or 400 grams capacity. In most cases, iron excepted, graphite is preferable. In cases where the metal used is susceptible to oxidation, e.g., silver and copper, it is necessary to further protect against oxidation by a layer of powdered charcoal or graphite or by heating in a reducing (CO) atmosphere.

Frankenheim Method.—The couple, enclosed in a porcelain or quartz glass tube, is immersed in the metal, the furnace allowed to cool slowly, and the e.m.f. observed at regular intervals (30 seconds or 60 seconds). During the process of solidification the e.m.f. will remain constant. Similarly during fusion.

Sources of Error.—The error most frequently overlooked and easiest to correct is that due to the variation in the temperature of the cold junction. For laboratory measurements, the cold junction should be maintained at zero degree. In commercial work it should be maintained at a constant temperature, if practicable, e.g., 100 deg. C. Otherwise the temperature of the cold junction should be noted and the correction applied: $t = t_{obs} + 0.5 \times$ temperature cold junction.

An error, almost inevitable under practicable working conditions, is that arising from the contamination of the wires and their consequent inhomogeneity. Metallic vapors, iridium especially, readily attacks platinum, producing a change in its thermo-electric properties. The drop in the e.m.f. due to contamination may amount to 50 deg. C., or even 100 deg. C. It is, therefore, highly desirable that when couples are used in furnaces in which slagging materials or reducing gases, or both, are present, the wires should be enclosed in a protecting tube, wrought iron, for example.

A couple once contaminated cannot be restored to former conditions except by removing the injured portion. The readings of a couple, when it is new and free from impurity, e.g., homogeneous, are independent of the depth of immersion. In a contaminated couple it is necessary to avoid temperature variations along the wires, since the inhomogeneity produces a condition in which the couple behaves like a series of almost infinitesimal couples. In the calibration of a contaminated couple, the depth of immersion should be the same as in working conditions.

A fourth source of error, brittleness in the wires, can be remedied by annealing.

Dr. Clement finally calls attention to two further sources of error in temperature measurements, which, however, are not in the thermo-electric circuit. In furnaces operating under reduced pressure the entrance of cold air through an opening around the pyrometer tube will produce a lowering of temperature. Also in the measurement of the temperature of gases, a low temperature may be produced by the conduction of heat along a tube or wires and by radiation to cooler walls.

CORRESPONDENCE

Dictionary of Chemical and Metallurgical Material.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—I have just received your Dictionary of Chemical and Metallurgical Material.

Knowing where to get things is second only in importance to knowing where to get information, and your Dictionary furnishes the latter about the former, and consequently has a quadratic importance.

Hollywood, Cal. Henry Noel Potter.

[Out of several hundred letters which we have received with respect to our Dictionary, we publish the note of Dr. Potter because it emphasizes pointedly our intentions in publishing this Dictionary. It is intended as an annual; and to improve it in future editions, we request detailed criticisms from all who use the Dictionary. One copy of the Dictionary has been sent free of charge to every one on our mailing list. Any of our readers who can add to its usefulness by detailed criticisms, is asked to kindly send them at an early date.—Editor.]

Atomic Weights.

To the Editor of Electrochemical and Metallurgical Industry:

Sir: Referring to Dr. Hinrichs' outline of his method for the calculation of atomic weights, published in your July issue, allow me to point out, for the benefit of our case-hardened and unimaginative analysts, wherein I think the theories adduced are well worthy of sympathetic consideration.

Dr. Hinrichs' method amounts really to a systematizing of error, of the difference E, and no student of physical science can deny that in doing this he is working along a perfectly scientific line of research, be it theoretical or practical. The search for the correct n^{th} decimal in an atomic weight by mechanical methods is worthy and useful—furthermore, it is "respectable," but it does not include mathematical consecration of the results and compels an agnostic attitude. It is this mathematical consecration or adjustment of results, which men with Dr. Hinrichs' mental attitude are seeking to give us. All honor and gratitude be to them.

It is true that Dr. Hinrichs believes in even numbers and natural fractions for all atomic weights, and as far as I can see, this still remains an open question. If differences exist they must do so according to some system, even if we have trouble in discovering its elements. If departures from whole numbers and natural fractions do really exist, they may, as I have recently pointed out (*Nature*, Feb. 18, 1909, p. 459), be connected with the disintegration of the atom as advocated by the most advanced school of physical chemists; and I suggested a test of the validity of this theory. It would seem that atomic disintegration would necessarily imply differences of electronic content for each element varying with the elapsed time from the previous critical limit at which the break-down from a higher element to a lower one took place.

If this loss of electrons is taking place, the elements in one world of space, having all a common origin in point of time, would have substantially identical atomic weights for different lots tested, but those from other worlds would differ from them. The iron or nickel in a meteorite, especially if its origin were extraneous to the solar system, might yield atomic weights quite out of keeping with those of iron and nickel found on this planet.

If a test of this character can be carried out, it seems to me that the theory of the continual degradation of matter will be either proven or else rendered very doubtful. If the theory is sound, the electronic losses of an element must be in definite relation to the age of that element, and therefore work of systematizing, such as that of Dr. Hinrichs, is, as I have already stated, of the highest scientific order.

Paris, France. Alfred Sang.

Conductivity, Porosity, and Gas Permeability of Refractory Materials.

By S. Wologdine and A. L. Queneau.

Introduction.

By A. L. Queneau, Consulting Metallurgical Engineer, Philadelphia, Pa.

A great difficulty in designing furnaces and estimating the probable loss of heat by conduction through the furnace walls is due to the practically total lack of reliable information as to the heat conductivity of refractory materials.

It is true that a number of determinations have been made since Peclet undertook the first experimental work, but, unfortunately, the experiments have always been carried on under conditions that do not occur in industrial furnaces,

The importance of the knowledge of the heat conductivity coefficients cannot be overestimated in modern metallurgy, especially in neometallurgy, the field of the electric furnace, where the cost of the heat units is of such economical importance Heat conductivities of furnace materials should be as available and as readily used as are the electrical conductivities. I might add, however, that a great deal of research work remains to be done in that latter field, especially in the electric conductivity of molten metals, slags and salts.

In view of the lack of knowledge that has prevailed in metallurgical engineering as to the properties of the materials in daily use, it is very gratifying to be able to welcome the remarkable paper read by M. S. Wologdine before the recent Congress of Applied Chemistry in London. He gives us, for the first time, a systematic study of the heat conductivity, porosity and gas permeability of the commercial refractory materials; the author is to be congratulated upon giving the full details of all tests and description of the apparatus used as well as of the difficulties that had to be surmounted.

It is to be regretted, however, that the range of the temperatures at which the determinations were made did not extend beyond 1000°, with the exception of a few instances in which temperatures of nearly 1200° were recorded

When it is considered that the heat conductivities increase quite rapidly with the temperature, the importance of determining the coefficients of heat conductivity within the industrial range from 1000° to, say, 1700° C. is clearly seen. Silica, magnesia and chrome bricks would very seldom be used if the temperature of the furnaces was not to be higher than 1000°. However, in the absence of data covering the industrial temperature range, use of the figures obtained at 1000° C. may now be made without undue error resulting.

The following has suggested itself to the writer by the study of the paper of Wologdine:

(1) Proper regard being given to the fusibility of the brick, all clay bricks, terra-cotta, building bricks, firebricks, have practically equal coefficients of heat conductivity The coefficients are differentiated in this class of refractory materials solely by the temperature of burning and not by the character of the clays or by their chemical composition.

(2) In all refractory materials, including the special bricks such as chrome, magnesia, carborundum, graphite, the heat conductivity is a direct function of the temperature of burning I am inclined to include as subject to this rule the amorphous carbon and the graphite electrodes, though this has not yet been confirmed by actual determination to my knowledge.

(3) The great value for heat insulation purposes of silica brick when burned at a moderate temperature, 1050° C., is due to the fact that their coefficient of heat conductivity is practically equal to that of Kieselguhr brick and only one-half that of clay brick. It is desirable that further determinations be made in this regard by independent observers

(4) The unique characteristic of chrome bricks is that their coefficient of heat conductivity is independent of the temperature.

(5) There are remarkable and often enormous variations in the permeability to gases of the same bricks with the increase in temperature. In one instance the permeability changed from 3.3 liters per hour to 241 liters per hour. This shows the importance of scientifically selecting the clay mixtures for a given work as for crucibles or retorts where, as in zinc metallurgy, the permeability to gases has a material influence on the metal recovery. In this connection the nil permeability of graphite crucibles is to be noted. Perhaps the same results might be obtained at a much reduced cost by substituting clay flakes for the graphite flakes as proposed by H. Putz (German patent 198, 840, Sept. 29, 1907).

(6) To secure efficient heat insulation, refractory materials should be burned at the lowest allowable temperature. This burning temperature is generally known; it is the maximum temperature to which the bricks will be exposed in the furnaces. The use of the maximum temperature is necessary in order to prevent the brick from shrinking any further when set in the furnace walls. Though this last fact is well known, it is often neglected, and a shortening of the furnace life is the result.

(7) The gas permeability of the bricks of blast furnace linings must have an important bearing on their life, owing to the destructive action of carbon monoxide in contact with the iron oxide present in the brick. (B. Osann, *Stahl und Eisen*, 1627, 1907.)

The following table has been prepared from the figures given by M. Wologdine:

No.	Material	Conductivity: Gr. cal. sec per sq. cm per cm. per 1° C. diff	Conductivity: Kg. cal. Hour per sq. m per m. per 1° C. diff	Relative Conductivity
1	Graphite brick	.025	9 0	100%
2	Carborundum brick	.0231	8 32	92 4
3	Magnesia brick	.0071	2 54	28 4
4	Chromite brick	.0057	2 05	22 8
5	Fire brick.	.0042	1 50	16 7
6	Checker brick	.0039	1 42	15 8
7	Gas retort brick	.0038	1 36	15 2
8	Building brick	.0035	1 26	14 0
9	Bauxite brick	.0033	1 19	13 2
10	Glass pot	.0027	96	12 4
11	Terra cotta	.0023	84	9 3
12	Silica brick.	.0020	71	7 8
13	Kieselguhr brick	.0018	64	7 1

The figures selected are representatives of the grade of refractory materials that are available for every-day furnace work; the figures for extra pure or inferior grades have been omitted as tending to obscure the issue.

This table in the absence of data for the higher industrial range from 1000° to 1700° C. offers the most reliable data at hand.

* * *

Conductivity, Porosity and Gas Permeability of Refractory Materials.*

By S. Wologdine

(Translated by A. L. Queneau.)

The important place which refractory materials occupy in modern industry demands an accurate knowledge of their physical and chemical properties; this knowledge is required not only in their manufacture, but also for their economical applications.

Consideration of the insulating properties of the refractory materials, i. e., the heat conductivity and gas permeability, is of the utmost importance in the construction of furnaces and in the manufacture and use of bricks, retorts, crucibles, etc. These properties have a direct bearing on the fuel utilization.

Until lately the fusibility and the alterability under the influence of the various disintegrating forces, physical, chemical and mechanical, have only been considered insofar as these characteristics have a more direct influence on the successful operation of industrial furnaces.

It had long been noted that the harmful influence of high

*A paper read at the London Congress of Applied Chemistry

temperature and the corrosion of furnace walls by the charge materials were affected by the difference in temperature between the interior and the exterior of the furnace. This temperature difference, the heat gradient, is a direct function of the heat conductivity of the materials forming the walls; the steeper the heat gradient the thinner is the portion of the wall subjected to the influence of the furnace temperature—a temperature which may be near the softening point of the wall components.

La Société d'Encouragement pour L'Industrie Nationale granted me a research scholarship to make a study of the heat conductivity, porosity and gas permeability of the ordinary refractory materials and clay products. The work was carried on in the laboratories of Professor LeChatelier at the Sorbonne and the Ecole des Mines and under his general supervision.

The materials tested may be classified as follows:

1st, Mixtures for refractory materials.

2d, Mixtures for stoneware and porcelains.

3d, Mixtures for earthenware and terra cotta.

4th, Mixtures for building bricks.

Round flat plates or bricks were made (Fig. 1) from these various mixtures in most cases in duplicate sets which were burned at different temperatures in order to observe the influence of the burning temperature on the physical properties. The plates were presented by metallurgical and ceramic works and were made from current commercial mixtures.

TABLE I.

Number	Type of Brick	Marks	Proximate Chemical Analysis	Temperature of Burning	Depth of the Thermo-Couples Holes		
					a_1	a_2	a_3
			Refractory Bricks.	*Deg. C.*	*Cms.*	*Cms.*	*Cms.*
1	Fire brick			1200	.5	4.	4.6
2	" "	RA–5	SiO_2 = 78, Al_2O_3 = 18, Fe_2O_3 = 3.3, CaO = .5%	1050	.7	4.5	4.9
3	" "	RA–9	" " " " " "	1300	.7	4.4	4.85
4	" "	RB–5	SiO_2 = 66, Al_2O_3 = 29, Fe_2O_3 = 4, CaO = .5%	1050	.5	4.45	4.9
5	" "	RB–9	" " " " " "	1300	.65	4.7	4.95
6	Checker brick	2			.7	4.5	5.0
7	" "	4			.5	4.5	5.5
8	Gas retort mixture	20			.55	4.5	5.0
9	" " "	20			.92	4.5	5.0
10	Bauxite	Bx–5	SiO_2 = 28, Al_2O_3 = 66, Fe_2O_3 = 5	1050	.6	4.5	4.8
11	"	Bx–9	" " " " "	1300	.5	4.5	4.9
12	Silica	S–5	SiO_2 = 94, Al_2O_3 = 2, CaO = 2	1050	.5	4.6	5.0
13	"	S–9	" " " "	1300	.6	4.5	5.1
14	Magnesia	M–5	SiO_2 = 1, Al_2O_3 + Fe_2O_3 = .5, MgO = 95	1050	.7	3.8	5.0
15	"	M–9	" " " "	1300	.5	4.75	5.0
16	Magnesia from Euboea	M	Fe_2O_3 higher than in No. 14 and No. 15		.7	4.2	5.
17	Euboea & Vallauris Mag.	MV–47			.6	3.75	5.
18	" " " "	MV–50			.6	4.1	4.95
19	" " " "	MV–56			.9	4.4	5.1
20	Glass Monkey Pot	P_1	Same mixture	Green	.6	3.8	5.25
21	" " "	P_2	" "	1200	.75	4.3	5.3
22	" " "	P_3	" "	1600	.65	4.25	5.2
23	" " "	B–4	" "	Green	.8	4.5	5.35
24	" " "	B–5	" "	1200	1.0	4.4	5.25
25	Carborundum	CA–5	SiC = 87, SiO_2 = 12, Fe_2O_3 = .4	1050	.5	4.5	5.
26	"	CA–9	" " " "	1300	.7	1.95	5.15
27	"	C–5	SiC = 75, SiO_2 = 20, Al_2O_3 = 3, Fe_2O_3 = 1, CaO, MgO = 1	1050	.5	4.6	5.1
28	"	C–9	" " " " " "	1300	.6	4.7	5.2
29	Graphite	P–18	C = 48.5, SiO_2 = 30.5, Al_2O_3 = 18, Fe_2O_3 = 2	710	.5	4.3	4.5
30	"	P–5	" " " " " "	1050	.6	3.9	4.35
31	"	P–9	" " " "	1300	.6	3.9	4.35
32	Chromite	Ch–1–23	Same mixture		.5	4.5	5.1
33	"	Ch–1–36	" "		.6	4.5	5.1
34	"	Ch–1–39	" "		.5	4.5	5.05
35	"	Ch–2–59	" "		.5	4.4	5.0
36	"	Ch–2–26	" "		.5	4.5	5.1
37	"	Ch–2–45	" "		.5	4.3	5.0
38	"	Ch–2–60	" "		.5	4.4	5.0
39	"	FA–5	" "	1050	.65	4.55	4.9
40	"	FA–9	" "	1300	.65	4.25	4.8
41	"	F–9	" "	1300	.5	4.85	5.25
42	Kieselguhr	K			.5	3.9	4.4
43	Graphite	QR/204–54			.5	4.5	4.85
44	"	QR–68 / 204			.65	4.2	4.85
			Stonewares and Porcelains.				
45	Stone-ware	GT–5	Same mixture	1050	1.0	4.3	5.05
46	"	GT–9	" "	1300	.9	4.1	4.8
47	"	G–44–5	" "	1050	1.25	4.15	5.2
48	"	G–44–9	" "	1300	1.1	4.05	5.0
49	"	G–152–5	" "	1050	1.0	4.15	4.95
50	"	G–152–9	" "	1300	.9	4.15	5.0
51	"	G–139–5	" "		.8	4.0	4.8
52	Porcelain (Sévres)	PN	SiO_2 = 69.4, Fe_2O_3 + Al_2O_3 = 23.61, CaO = 1.22, K_2O = 2.58, Na_2O = 2.42	1300	.45	4.15	4.6
53	" "	PD	SiO_2 = 60.75, Fe_2O_3 + Al_2O_3 = 32, CaO = 4.15, K_2O + Na_2O = 3.02	1400	.45	3.95	4.45
54	Stone-ware (Sevres)	PD–67	SiO_2 = 79.32, Al_2O_3 + Fe_2O_3 = 18.42, K_2O + Na_2O = 2.14	1300	.05	4.45	4.85
			Building Bricks and Terra Cotta.				
55	White building brick	TCB–5		1050	.9	4.2	4.85
56	" " "	TCP		1050	.6	4.3	4.9
			Mixtures For Red Building Bricks.				
57	Red brick	T–2/5	SiO_2 = 75, Al_2O_3 = 14, Fe_2O_3 = 6, CaO = 3, MgO = 2	1050	.6	3.8	4.8
58	" "	T–2–40 / 5	" " " " "	1050	.5	2.15	4.65
59	" "	T–3–42 / 5	SiO_2 = 74, Al_2O_3 = 16, Fe_2O_3 = 6.5, CaO = 2.5, MgO = 1	1050	.6	4.3	4.9
60	" "	T–3–7 / 5	" " " " "	1050	.8	4.8	5.1
61	Vallauris clay	V–48			.5	4.7	5.1
62	" " "	V–51			.6	4.9	5.1
63	" " "	V–57			.7	4.55	5.0
64	Light clay	L–52			.6	4.0	5.0
65	" "	L–58			.75	4.5	5.0

The plates, which were 50 mm thick, had four identical series of holes, all 2.5 mm in diameter. In each series the first hole was pierced through the plate, the second hole was 5 mm. deep and the third 45 mm deep.

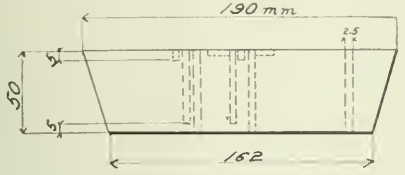
The plates were first used in the determination of the heat conductivity and then cylinders 45 mm in diameter of the full thickness of the plates were cut out of them, the cylinders serving for the density, porosity, and permeability determinations.

In Table I is given the list of the materials investigated, together with the proximate chemical analysis, the burning temperature, and the depth of the holes for the thermo-couples. It will be noticed that the depth of the third hole is equal to the thickness of the plate.

Heat Conductivity.

The apparatus used for the determination of the heat conductivity is shown in Fig. 2. The test plate *g* placed in the cover *e* was heated by means of the gas furnace *f*. The heat flow through the plate was measured by the water calorimeter *C*

Temperature determinations were made simultaneously at the following points: First, at the lower surface of the plate *g*.



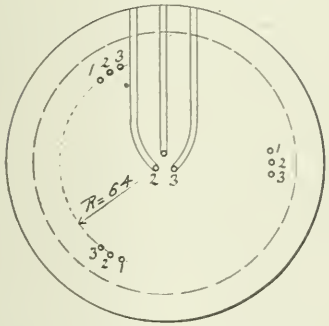


FIG. 1.—TEMPERATURE MEASUREMENTS IN SAMPLES

second, 5 mm above the lower surface; third, 5 mm below the upper surface; thus it was possible to establish the relation between the heat flow and the heat gradient in the interior of the plate, and to calculate the coefficient of heat conductivity; i.e., the quantity of heat expressed in gram-calories passing in one second through a section of 1 sq. cm with a variation of temperature of one degree per centimeter of depth. The uniform heating of the plate was secured by placing the small pieces of brick *d* near the chimney *T*. Temperature measurements made with LeChatelier thermo-couples placed in the four series of three holes, Fig. 1, showed that the heat distribution was sufficiently uniform to warrant the use of a single series of holes, the series centrally located. The thermo-couples were made of platinum and 10 per cent platino-rhodium wires 0.1 mm in diameter. The wires of the thermo-couples were insulated in the holes by fine silica sand moistened with water glass and above the holes by asbestos thread. By means of a suitable switching device *R*, the one galvanometer *G* served for the three thermo-couples.

Before testing, the plates were treated as follows

The two faces were made approximately parallel by rubbing, this is absolutely necessary to secure perfect contact between the calorimeter and the plate

Three grooves leading to the holes of the central series were cut in the plate to receive the insulated thermo-couple wires, which were thus below the calorimeter (Fig. 1).

The depth of the central holes and the thickness of the plates were carefully measured.

The water calorimeter *C* had a diaphragm with a central open-

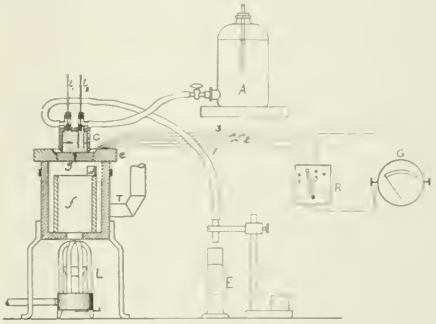


FIG. 2.—DETERMINATION OF HEAT CONDUCTIVITY.

ing to insure the thorough mixing of the different water currents; the uniform temperatures indicated by the thermometer t_1 and t_2, graduated in tenths, demonstrated the necessity of the diaphragm. The quantity of water passing from the Mariotte bottle *A* through the calorimeter during a given time was collected and weighed. When the temperature equilibrium had been established, simultaneous pyrometer readings were made on the thermo-couples 1, 2 and 3.

The modus operandi of a test was as follows:

The furnace being started, the temperature was allowed to rise gradually without placing the calorimeter on the plate under test. When the equilibrium of temperature between the heat given by the flame and lost by radiation to the air was established, the calorimeter was put in place and the water made to flow, new temperature determinations were made, and the test was completed when the equilibrium was reached under the new

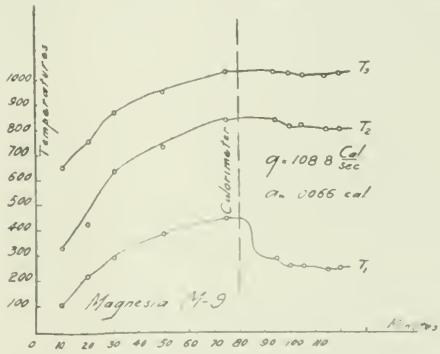


FIG. 3.—TEMPERATURE VARIATIONS DURING A TEST.

conditions, from time to time the regularity of the water flow was checked by collecting the water during a given time in a graduated glass.

The diagram Fig. 3 gives the temperature variations during a test made on a magnesia brick. The temperature equilibrium was obtained 80 minutes after starting; by the placing of the calorimeter a new equilibrium was established 30 minutes later. The curve T_1 gives the temperature changes in the section of

the plate 5 mm below the calorimeter; the sudden drop took place soon after placing the calorimeter in position. The curve T_3, corresponding to a point 45 mm below the calorimeter, presents but a small modification, while the curve T_2 shows the uniform temperature at the lower surface of the plate throughout the test.

In order to compute the coefficient of heat conductivity, the hypothesis was made that the line representing the heat variations through the thickness of the plate, i.e., the heat gradient,

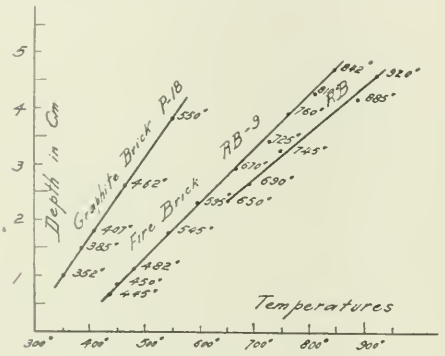


FIG 4.—HEAT GRADIENT CURVES.

is a straight line passing through the two points representing the temperatures T_0 and T_3 of the two parallel faces of the plate. This makes it possible to determine the two temperatures T_0 and T_3 by interpolation. The truth of the hypothesis was experimentally demonstrated by directly measuring at various points the temperatures in different plates which were heated until the equilibrium had been established.

The results are shown in Fig. 4.

The detail of the calculation for the determination of the coefficient of heat conductivity for the magnesia brick M-9 is given in Fig. 5.

Let T_1, T_2, T_3 represent the temperatures given by the thermocouples, t_1 and t_2 the temperatures of the water as it enters and leaves the calorimeter, P the quantity of water that passed through it in grams per minute. By interpolation the temperatures T_0 and T_3 of the upper and lower faces of the brick are obtained. The quantity of heat Q traversing per second an area equal to that of the calorimeter bottom is

$$Q = \frac{P\,(t_2 - t_1)}{60}$$

The coefficient of heat conductivity is

$$a = \frac{S\,(T_3 - T_0)}{QL}$$

S being the area of the bottom of the calorimeter in square centimeters and L the thickness of the plate in centimeters.

In the test given in Fig. 5 (magnesia brick M-9) $T_1 = 265°$, $T_3 = 807°$, $T_3 = 1029°$ (temperature of the furnace), $t_1 = 14.9$, $t_2 = 21.3$, $l = 5$, $S = 125.68$ cm², $P = 1020$ gr., then

$$Q = 108.8 \text{ gram calories,}$$

and $a = .00066$ gram caloric unit of conductivity.

The differences of temperature between the upper face of the brick and the average temperature of the calorimeter water on one hand, and between the temperature of the lower face and heat of the flame on the other hand, supply useful data regarding the heat equilibrium.

In the test M-9 the differences were as follows:

$$T_0 - 18° = 182°$$
$$T_3 - T_3 = 180°$$

When the two temperatures obtained in this way showed too great a difference the test was repeated.

The heat conductivities obtained have been computed:

First, in gram calories for 1 deg C. difference of temperature, 1 sq. cm surface, 1 cm thickness in one second.

Second, in kilogram calories for 1 deg. C. difference of temperature, for 1 sq. m, 1 m thickness in one hour. (Table III.)

For most of the refractory materials the heat conductivities vary between 500 deg. and 1000 deg.; within those limits the changes are not very large, and for practical purposes it is sufficiently accurate to take the arithmetical mean of the coefficients corresponding to the temperatures between these two limits; these are the figures given in the fourth and fifth columns of Table III.

Firebrick.

Marks	Temperature of Upper Surface	Temperature of Lower Surface	Conductivity Gram-Calories
Bricks Burned at 1050°:			
RA 5.	145	1010	.0038
"	125	840	.0036
Average..	...	...	.0037
RB-5	250	1220	.0037
"	205	1095	.0032
Average...	..	.	.0035
Bricks Burned at 1300°;			
RA-9	310	1000	.0054
"	205	725	.0048
Average...	...	...	.0051
RB-9	225	1085	.0039(?)
"	230	925	.0044
"	225	620	.0042
Average....	.....	.....	.0042

From Table (*a*) it is seen that the conductivity of firebricks increases with the temperature, and that the conductivity increases with the temperature of burning.

Checker Brick.

Marks	Temperature of Upper Surface T_0	Temperature of Lower Surface T_3	Conductivity Gram-Calories
2	185	1,005	.0035
2..	85	706	.0030
2	110	563	.0036
Average.....	.....	.....	.0034
4	112	825	.0043
4	115	730	.0036
Average..	.....	.....	.0039

Table (*b*) refers to checker bricks from the Paris Gas Company regenerative illuminating gas furnaces*, while Table (*c*) refers to bricks made from the same mixture as used by the Paris Gas Company for their illuminating gas muffles.

Brick from Gas Retort Mixture.

Marks	Temperature of Upper Surface T_0	Temperature of Lower Surface T_3	Conductivity Gram-Calories
20/3	140	1120	.0040
"	175	1110	.0040
"	160	1050	.0039
"	150	1010	.0040
"	140	990	.0038
"	151	870	.0037
"	105	685	.0035
Average.....	.....	.....	.0038
20/5	195	1125	.0041
"	110	930	.0038
"	150	9 ,	.0037
"	150	865	.0036
Average...	.....	.....	.0038

The last two tables show clearly the increase of the heat conductivity with the temperature. This is further illustrated in Fig. 6 in the gas-retort bricks.

Bauxite Brick.

Marks	Temperature of Upper Surface	Temperature of Lower Surface	Conductivity Gram-Calories	Remarks
Bx-5	150	1140	.0030	Burned at 1050
"	160	1120	.0033	
Average.	.....	.....	.0031	
Bx-9	170	1155	.0035	Burned at 1300
"	170	965	.0031	
Average.	.....	.....	.0033	

By burning at 1300 deg. the heat conductivity of the bricks is increased 1.5 times that of those burned at 1050 deg. The heat conductivity increases slightly with the temperature.

Silica Brick.

MARKS	Temperature of Upper Surface	Temperature of Lower Surface	Conductivity Gram-Calories	Remarks
S-9.	147	1015	.0033	Burned at 1300°
"	165	1015	.0033	
"	140	1000	.0031	
"	145	1000	.0031	
"	160	805	.0029	
"	165	735	.0031	
Average.			.0031	
S-5.	110	1005	.002	Burned at 1050°

*Damour-Queneau—Industrial Furnaces, pages 88 and 89.

The measurements with the bricks M-5, M-9 represented great difficulties, owing to their small cohesion, being almost pure magnesia (95 per cent MgO), especially in case of the brick M-5, burned at 1050 deg.

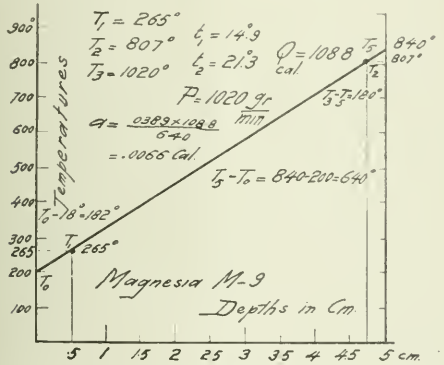


FIG. 5.—TEST OF MAGNESIA BRICK.

The coefficients for the brick M-9, burned at 1300 deg., vary regularly from 0.006 to 0.0072.

The brick M-53, regular commercial magnesia brick, is higher in iron, lime and silica than the purer brick, and has also higher heat conductivity coefficients.

Magnesia Brick.

MARKS	Temperature of Upper Surface	Temperature of Lower Surface	Conductivity Gram-Calories	Remarks
M-5.	230	1000	.0058	Burned at 1050°.
M-9.	185	915	.0060	" " 1300°.
"	200	840	.0066	Both bricks were of
"	155	795	.0062	high-grade Mag-
"	180	745	.0064	nesia, white and
"	200	720	.0064	very pure.
"	165	700	.0072	
"	134	530	.0070	
Average			.0065	
M-53.	260	970	.0072	This brick is much
"	215	885	.0075	higher in iron than
"	130	675	.0065	the brick M-5-9
Average			.0071	
MV/47.	115	910	.0035	The bricks MV/47,
"	105	695	.0036	50, 56 are of very
Average			.00355	much lower grade
MV/50.	90	905	.0035	than the first bricks,
"	50	485	.0036	being lower in MgO
Average			.00355	and higher in F_2O_3
MV/56.	130	1130	.0030	
"	115	980	.0031	
"	70	705	.0027	
Average			.0029	

The bricks MV-47, 50, 56 are not true magnesia bricks in the generally accepted meaning of the term, being high in clayey material; their conductivity is practically that of firebricks.

The bricks were made from the mixtures used in the manufacture of glass pots.

Besides the green bricks and those burned at 1200 deg., a third specimen burned during 60 days at 1600 deg. was also tested. The increase of conductivity with the temperature of burning

Bricks Made from Glass Pots Mixture.

MARKS	Temperature of Upper Surface	Temperature of Lower Surface	Conductivity Gram-Calories	Remarks
P-1	57	565	.0025	Green brick.
P-2.	190	1035	.0026	Burned at 1200°.
"	90	640	.0023	
Average			.00245	
P-3.	255	900	.0048	Burned for a long
"	140	615	.0042	time at 1600°
Average			.0045	
B-4	80	560	.0031	Green brick
B-5.	175	1150	.0029	Burned at 1200°
"	100	670	.0025	
Average			.0027	

is very marked, the conductivity of the brick burned at 1600 deg. being practically double of that of the brick burned at 1050 deg.

The experimental determinations for bricks of such high conductivity presented difficulties due to the heating of the calorimeter by radiation; the extreme hardness of the brick made difficult any attempts to remedy defects in them. This

Carborundum Brick.

MARKS	Temperature of Upper Surface	Temperature of Lower Surface	Conductivity Gram-Calories	Remarks
CA-5.	280	750	.015	Burned at 1050°
"	270	690	.014	
"	265	680	.014	
"	255	660	.015	
Average			.0145	
CA-9.	300	650	.019	Depth of a_2 was too
"	230	440	.027	small (1.95 mm.)
Average			.023	
C-5.	205	1210	.0032	Burned at 1050°
"	200	1165	.0032	
"	155	1075	.0036	
"	160	1065	.0034	
"	155	870	.0033	
Average			.0033	
C-9.	420	1000	.015	Burned at 1300°
"	355	775	.017	
"	290	730	.014	
"	280	720	.013	
"	225	555	.013	
Average			.014	

explains the irregularity of the results obtained. The influence of the carborundum contents is very marked. The conductivity increases also with the temperature of burning.

Owing to the possibility of burning the graphite in the face

Graphite Brick.

MARKS	Temperature of Upper Surface	Temperature of Lower Surface	Conductivity Gram-Calories	Remarks
P-18	180	900	.0061	Test conducted with
"	175	855	.0055	oxidyzing flame; re-
"	162	685	.0063	sulting in the burn-
"	130	620	.0053	ing of some of the
"	115	420	.0061	graphite.
Average			.0059	
P-5.	200	660	.013	Loss in graphite
"	215	595	.015	
"	210	565	.015	
Average			.014	
P-9	405	865	.019	As above
"	175	405	.018	
Average			.0185	
QR-54/204	330	600	.024	Test conducted in
"	295	550	.024	reducing atmos-
Average			.024	phere. No loss of
QR-68/204	430	705	.026	graphite
"	285	485	.024	
Average			.025	

of the brick in contact with an oxdizing flame, widely different results may be recorded. The great heat conductivity may also affect the calorimeter by radiation.

The figures for the bricks QR/54 and QR/68 only are representative of this class of bricks, as bricks P-5, 9, 18 had the

graphite burned out for a depth of several millimeters,[1] the bricks appearing white on the lower face after the test.

The influence of the temperature of burning is also to be noted.

Chromite Brick.

Mark	Temperature of Upper Surface	Temperature of Lower Surface	Conductivity Gram-Calories	Remarks
FA-5	160	1120	.0026	Bricks made of Chrome Ore with a clay binder.
	215	1075	.0031	
	115	955	.0026	
Average			.0028	
FA-9	125	1180	.0034	FA-5 burned at 1050
	115	805	.0034	FA-9 " " 1300
Average			.0034	
F	70	1125	.0025	Pure Chrome Ore, very porous brick.
	105	675	.0025	
Average			.0025	
Ch-1-23	235	895	.0068	CH 1-23 and CH-1-36 are denser than the following bricks: Ch-1-39, Ch-2-59-26-45
	150	510	.0070	
Average			.0069	
Ch-1-36	170	920	.0072	
	125	575	.0062	
	125	565	.0063	
	150	500	.0066	
Average			.0066	
Ch-1-39	170	600	.0062	
Ch-2-59	295	1190	.0060	
	210	855	.0058	
	205	820	.0052	
	220	805	.0058	
	145	570	.0057	
Average			.0057	
Ch-2-26	155	900	.0056	
	110	655	.0054	
Average			.0055	
Ch-2-45	240	985	.0044	
	280	950	.0050	
	175	840	.0046	
Average			.0047	
Ch-2-60	260	1025	.0053	
	185	960	.0056	
Average			.00545	

The bricks Ch-1 and Ch-2 may be considered true chromite bricks; the bricks FA-5-9 being too high in clay contents, the heat coefficient of the latter is practically that of firebrick. The heat coefficients for Ch-1 and Ch-2 appear to remain independent of the temperature. Brick F, of pure chromite, was very porous.

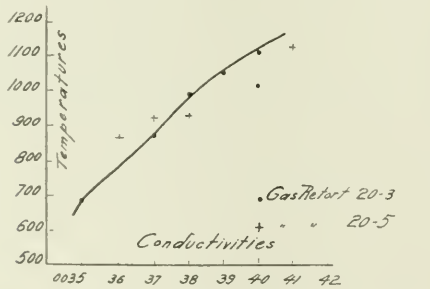


FIG. 6.—INCREASE OF HEAT CONDUCTIVITY WITH TEMPERATURE.

Kieselguhr Brick.

Mark	Temperature of Upper Surface	Temperature of Lower Surface	Conductivity Gram-Calories
K	140	910	.0020
	100	630	.0016
Average			.0018

These bricks have a remarkably low coefficient of conductivity and a low apparent density.

Their manufacture is difficult, owing to the change of volume that takes place during burning, when the hydrated silica loses its water. A single specimen among six received was available.

[1] The influence of a porous zone free from graphite, and of a few mm. in thickness, is very noticeable on the heat conductivity; this passing from .025 to .018, a difference of 30 per cent. Translator.

All the mixtures tested, mixtures for products of widely different applications in the arts, when burned until vitrified,

Bricks Made of Stoneware Mixtures.

Marks	Temperature of Upper Surface	Temperature of Lower Surface	Conductivity Gram-Calories	Remarks
GT-5	115	845	.0033	Not vitrified.
"	70	610	.0031	" "
Average			.0032	" "
GT-9	200	1000	.0052	Vitrified.
"	135	675	.0047	"
Average			.00495	"
G-44-5	110	930	.0029	Not vitrified.
"	75	670	.0032	" "
Average			.00305	" "
G-44-9	160 (?)	1000	.0053	Vitrified.
"	160	675	.0042	"
Average			.00475	"
G-152-5	115	990	.0034	Not vitrified.
"	105	800	.0033	" "
Average			.00335	" "
G-152-9	70	655	.0040	Vitrified.
G-189-5	105	860	.0038	Not vitrified.
67	280	795	.0045	Vitrified.

have a higher conductivity than any of the clay and silica mixtures. The conductivity of the plates made from the same mixture but burned at a temperature lower than the vitrification point is practically that of clay bricks. All these bricks show the influence of the temperature of heating on the conductivity.

White Terra Cotta.

Marks	Temperature of Upper Surface	Temperature of Lower Surface	Conductivity Gram-Calories
TCB-5	60	860	.0033
TCP	203	875	.0038
"	195	830	.0036
Average			.0037

These mixtures used in the manufacture of architectural white bricks, terra cottas, etc., were burned at a low temperature; the coefficient of conductivity is equal to that of fire bricks burned at low temperature.

Red Bricks and Terra Cotta.

Marks	Temperature of Upper Surface	Temperature of Lower Surface	Conductivity Gram-Calories
T-2-5	255	1000	.0034
"	260	840	.0033
"	175	720	.0038
Average			.0035
T-3-7	135	695	.0035
T-3-42	65	965	.0029
"	115	765	.0028
"	95	660	.0027
Average			.0028
V-48	80	860	.0033
"	55	530	.0024
Average			.00285
V-51	100	865	.0024
"	90	710	.0024
Average			.0024
V-57	125	1100	.0025
"	105	1080	.0026
"	60	795	.0023
"	15	655	.0018
Average			.0023
L-52	110	1135	.0026
"	95	885	.0024
"	60	550	.0022
Average			.0024
L-58	95	1120	.0023
"	95	995	.0024
Average			.00235

Under this heading were included mixtures for building bricks, roof tiles, etc.; the temperature of burning is low and the heat coefficient is the same as that of the preceding bricks.

From an examination of Table III (October issue) it is seen that all mixtures with a clay basis, when burned at 1050 deg. C., have an equal coefficient of conductivity equal to about 0.003.

When burned at a higher temperature than that of 1300 deg. the coefficient is notably higher, 0.0045.

Silica brick have a lower conductivity than the clay bricks if burned below the temperature at which quartz is transformed into trydimite. The conductivity of magnesia brick is about double that of clay bricks. Graphite and carborundum bricks have a conductivity nearly five times that of clay bricks. Finally, Kieselguhr brick has the lowest heat conductivity coefficient, 0.0018; i.e., equal to only half that of clay brick.

For all bricks the heat conductivity increases with the temperature of burning. This conductivity increases with the temperature.

(To be concluded.)

Furnace Electrode Losses.

By C. A. HANSEN.

Comparative Oxidation Rates of Carbon and Graphite: Historical.—Some work along this line has been done by previous investigators, but so far as the writer knows, no figures have been published other than those of Moissan (Le Four Electrique), who determined the lowest temperatures at which some varieties of carbon would oxidize. In general, his conclusions were that amorphous carbons oxidize at temperatures as low as 375° to 490° C., while graphite did not oxidize below 665° to 690° C. This work was all done on powders, apparently, not on carbons made up into shapes with binders and subsequently baked. Collins (ELECTROCHEM. AND MET. IND., II, 277), FitzGerald (*Ibid.*, III, 9) and Johnson (*Ibid.* II, 335) all say that graphite offered "greater resistivity to combustion than amorphous carbon."

Procedure.—The following work was suggested in 1905 by Prof. C. F. Burgess at the University of Wisconsin and was carried out in his laboratory by Mr. C. P. Hatter and the writer at that time.

Carbon and graphite rods were clamped into larger graphite blocks, to which current connections were made, the apparatus being arranged as shown in Fig. 1. A variable resistance was connected in series. When a rod was to be heated this resistance was all cut out, and as the rod heated the resistance

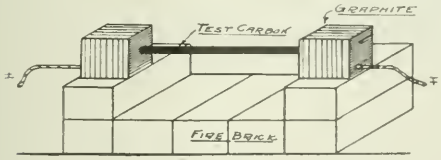


FIG. 1.—APPARATUS FOR TESTING RATE OF OXIDATION.

was put back into the circuit. In this way the test rod could be brought to the desired temperature in from 5 to 8 seconds. Since each rod was kept at an approximately uniform temperature, as indicated by a Wanner pyrometer, for 15 minutes, the heating interval cannot have been a serious variable any more than the cooling interval, which was perhaps 10 seconds before the temperature of the rod fell below 600° C.

The rods were dried, weighed and micrometered before test and after test they were brushed lightly, weighed and micrometered again. Loss per square centimeter of surface exposed per minute was calculated on the basis of the average of the two sets of dimensions.

In Fig. II the results have been plotted. The carbons gave points which are fairly close to a straight line. The graphite points were averaged arithmetically and the straight line drawn through the calculated points. It is significant that only one graphite point falls below the carbon line.

The results do not, however, show that graphite is more readily oxidized than amorphous carbon, for a rather curious reason. When a graphite rod is heated to 1300° or 1400° it throws off particles of graphite, many of which are so large that they are not completely burned when they leave the rod,

OXIDATION OF CARBON (NATIONAL CARBON CO.).

Sizes of Samples. cm.	Length Exposed. cm.	Temp.	Loss. Grs. cm.²/min.	Loss. cm. depth/hr.
[1] 1.0 x .63	29	925° C.	.0062	.232
" "	"	990	.0073	.273
" "	"	1019	.0093	.348
" "	"	1137	.0107	.402
" "	"	1209	.0115	.433
" "	"	1250	.0120	.450
" "	"	1305	.0121	.453
" "	"	1305	.0126	.472
" "	"	1305	.0132	.488
" "	"	1353	.0159	.596
" "	"	1369	.0148	.555
" "	"	1412	.0142	.532
" "	"	1412	.0146	.548
" "	"	1412	.0143	.536
" "	"	1425	.0145	.545
" "	"	1425	.0146	.548
" "	"	1491	.0165	.618
" "	"	1522	.0166	.622
" "	"	1522	.0193	.724
" "	"	1522	.0171	.642
" "	"	1713	.0192	.720
" "	"	1762	.0193	.724
" "	"	1789	.0231	.865
" "	"	1907	.0196	.735
" "	"	1930	.0190	.746
1.3 diam.	23	1305	.0133	.500
" "	"	1412	.0146	.548
.63 "	20	1412	.0145	.545
" "	"	1305	.0128	.486

[1] A fresh sample used for each measurement.

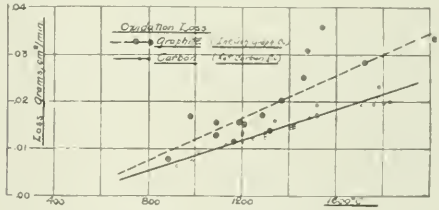


FIG. 2.—CURVES OF OXIDATION LOSS.

OXIDATION OF GRAPHITE (INTERNATIONAL ACHESON GRAPHITE CO.).

Sizes of Samples, cm.	Length Exposed, cm.	Temp.	Loss. Grs. cm.²/min.	Loss. cm. depth/hr.
[2] .6 diam.	10	893° C.	.0078	.283
" "	"	980	.0169	.615
" "	"	1090	.0151	.513
" "	"	1090	.0129	.470
" "	"	1194	.0155	.565
" "	"	1208	.0150	.545
" "	"	1281	.0170	.618
" "	"	1375	.0202	.735
" "	"	1485	.0311	1.130
" "	"	1544	.0358	1.305
" "	"	2030	.0335	1.220
1.2 "	23	1166	.0119	.433
" "	"	1305	.0139	.506
" "	"	1408	.0251	.923
" "	"	1738	.0274	1.000

[2] A fresh sample used for each measurement.
All samples were micrometered to .01. Dimensions given are approximate.

but can be collected on a sheet of asbestos, held underneath the heated rod. All of those graphite samples which gave very high loss values behaved in this way. Some of them did not throw off particles when heated, notably the one subjected to the highest temperature (2030° C.). None of this was noted with the carbon samples heated.

The explanation perhaps lies in the greater porosity of the graphite, which enables the binder carbon to be oxidized, the originally bound particles falling away when this takes place.[1]

[*] It was found that the carbon samples heated quite uniformly from contact to contact while the graphite samples might be 1300° C. in the middle and only 600° C. at the graphite block terminals. When small carbon bushings were interposed between the graphite sample ends at the terminal blocks, the temperature was found to be quite uniform throughout the entire length of sample. On the whole this experiment is the most striking illustration of comparative heat conductivities I have run across in this work.

[1] The porosity of graphite electrodes (as calculated from a bulletin issued by the Acheson Graphite Co.) = 1 — 1.6/2.25 = 28.8 per cent. The porosity of amorphous carbon electrodes (same bulletin) = 1 — 1.6/2 = 20 per cent.

Merely to show that the falling off of the graphite particles was due to oxidation, however, a rod which showed a decided tendency to flake off was heated in CO to a temperature in excess of 2000° C. The loss was .002 grs./cm²/min. This loss was probably due to traces of CO_2 or O_2 in the CO.

That graphite in itself is really less readily oxidized than amorphous carbon is indicated by this observation:

When a carbon article composed of graphite and amorphous carbon, bound together in the ordinary way, is burned because of careless handling in the process of manufacture, the surface of that article will always, in the writer's own experience, at least, be highly graphitic.[2] In fact, one of the workmen here brought in a motor brush which he had "graphitized" accidentally at a temperature not in excess of 400° C., as a refutation of the commonly accepted idea that extremely high temperatures were necessary for graphitization.

Progressive Oxidation.—The original surface of a baked carbon article is made up of a skin of relatively dense carbon, very thin, which in all probability is due to the breaking down at the surface of the volatile hydrocarbons driven out from the binder pitch in the baking process. The question of porosity raised above would indicate a less rapid oxidation rate for this surface. An attempt was therefore made to distinguish between the rate of oxidation of the fresh surface and of the surface left when the skin was burned away.

Progressive Oxidation of Carbon.—Successive four-minute heats on same sample.

Size of Sample cm.	Length Exposed, cm.	Temp.	Grs. Loss per cm.²/min.
1.0x.63	20	1261	.0113
	"	"	.0123
	"	"	.0129
	"	"	.0131
	"	"	.0128
	"	"	.0134
1.6x.63	"	1243	.0112
	"	"	.0118
	"	"	.0129
	"	"	.0120
	"	"	.0135
	"	"	.0143
	"	"	.0148
Graphite—same treatment.			
1.3 dia.	20	1243	.0139
	"	"	.0151
	"	"	.0158
	"	"	.0159
	"	"	.0159

The results obtained indicate a somewhat lower oxidation rate at the start.

Discussion.—As regards the application of the results above given it is, of course, realized that they cannot be made use of in predetermining the electrode consumption for a furnace. The consumption of electrodes depends so largely upon the degree of exposure to oxidizing influences; whether the electrodes are embedded in reducible material, as is the case with all ferro alloy furnaces; whether, in case of Girod or Héroult furnaces, the charging doors are tightly closed, etc.

It is, however, reasonably certain that in ordinary furnace use graphite electrodes are not inherently superior to carbon electrodes on the score of resisting oxidation.

As an instance of the importance of cutting down the oxidation loss of electrodes, the following case may be cited:

Some time ago a small Héroult furnace of 300 lb. charge capacity was built (described in Electrochem. and Met. Ind., May, 1909). This furnace was fitted with 4-in. x 4-in. x 40-in. graphite electrodes, and it was found possible to melt a 300-lb. charge in it with 150 kw-hours. Shortly afterward a slightly larger furnace of 600 lb. charge capacity was built and likewise fitted with 4-in. x 4-in. x 40-in. electrodes. It was repeatedly found that the power required was greater per unit charge than with the smaller furnace in the ratio of about 1.2 to 1.0. When the larger furnace was fitted with 6-in. x 6-in. x 40-in. graphite electrodes it showed a slight advantage in power consumption over the 300-lb. furnace so long as the electrodes retained the square 6-in. x 6-in. end.

As soon as the electrodes became pointed the power consumption increased. The difference between full square end and sharp point on electrodes made a power consumption difference of fully 30 per cent.

The difference must be due partly to the fact that the square-end electrode distributes the heat more uniformly, and partly to the screening by the electrode end of the roof from the direct radiation of the arc. It has been noticed repeatedly in laboratory work with small steel furnaces that sore eyes and roof troubles go with pointed electrodes, an evidence of the screening action of the full-sized electrode end.

Now all electrodes used in the Héroult furnace, at least, tend to oxidize to a point as shown in Fig. III (No. 4), and one of the electric steel furnace pioneers of this country argued that while he realized the power saving, due to the use of large tip electrodes, he might as well buy the smaller and cheaper electrode, since they all became pointed in a short time, anyway.

We have tried to coat electrodes with the intention of cutting down electrode oxidation. Electrodes No. 3 and No. 4, Fig. III, arc 4-in. x 4-in. x 40-in. graphites worked together for several runs in a 300-lb. Héroult furnace without water cooling. No. 3 was coated with a paste of carborundum and water glass (density about 1.15). Where the water glass-carborundum coating sticks its enormous advantage is easily recognized. We have not yet, however, found a convenient way of making it stick uniformly.

FIG. 3.—OXIDATION OF ELECTRODE ENDS.

Electrodes No. 1 and No. 2 of the same figure are respectively of carbon and graphite and were worked together without water cooling at 125 amp per square inch in a 600-lb. Héroult furnace. The high current density made the carbon electrode the hotter of the two and it oxidized more than the corresponding graphite. The graphite electrode is raised to make up just the original difference in length.

The disadvantage of the carbon electrodes is also well shown in the same cut. Note the break marked with white paint. The break was not due to excessive current densities.

Fig. IV shows the same disadvantage with an 18-in. x 18-in. x 72-in. carbon in which the current density never exceeded 27 amp per square inch.

In the latter case the breaking of the electrode necessitated the tearing down of the furnace. The time lost in replacing the electrode permitted the furnace charge to cool to such an extent that it was impossible to get enough power back into it to start it off again.

These last incidents are mentioned merely to emphasize the point that there are troubles other than oxidation troubles and to emphasize the need of carefully made carbon electrodes. There is nothing inherent in the nature of carbon that makes perfect electrodes impossible. The results argue for carbon electrodes when properly made for use in steel furnaces, etc., for, since a large electrode-end area is advantageous on the score of power economy, large section electrodes and consequent low-current density must be used. When low-current

[2] This applies up to 1400° C. at least. The following sentence, of course, might indicate that the mixed carbons had been exposed at temperatures below those at which graphite would oxidize at all, according to Moissan, which was not the case, as a rule.

densities are used the main inherent advantage of graphite over carbon—its low electrical resistivity—dwindles in impor-

FIG. 4.—ELECTRIC FURNACE.

tance and the main inherent disadvantage of graphite over carbon—its high heat conductivity—becomes of extreme importance.

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Melting Iron in a Foundry Cupola.

BY PROF. H. MCCORMACK.

This article follows along the same line as the one previously published on the same subject in the January issue, 1908, of this journal (Vol. VI, page 20). We have endeavored to make our data more complete than was possible in the former article, and have corrected some of the errors which appeared in the first attempt to accurately account for all the heat developed in the foundry cupola. The accompanying data was taken on a heat as ordinarily conducted by the foreman in our foundry:

REPORT ON HEAT IN FOUNDRY OF ARMOUR INSTITUTE OF TECHNOLOGY, NOVEMBER 12, 1909.

The charge was

Coke	240	kg
Scrap iron	727	"
Pig iron	363.5	"
Limestone	[illegible]	"

The charge was arranged as follows:

Bed charge of coke	36	kg
Scrap iron	163	"
Coke	22	"
Scrap iron	91	"
Pig iron	91	"
Limestone	18	"
Scrap iron	91	"
Coke	27	"
Pig iron	91	"
Limestone	18	"
Coke	27	"
Scrap iron	91	"
Pig iron	91	"
Limestone	18	"
Coke	27	"
Scrap iron	91	"
Pig iron	91	"
Limestone	16	"

There was obtained from the heat

Slag	110.5	kg
Coke	53	"
Clean castings	1070	"

The blast was turned on at 3:37 and the bottom dropped at 4:44, giving a run of 67 minutes. The temperature of the escaping gases was taken every three minutes with a Whipple temperature indicator; the average temperature was 155° C. at the time the blast was turned on and the highest temperature was 1280° when the bottom was dropped. The average temperature was 800° C.

The temperature of the metal was taken at each tapping with a Thwing radiation pyrometer. The lowest temperature was 1700° C. The average temperature was 1900° C.

The blast velocity, pressure and volume were taken. The average blast pressure was static head 4.5 in. of water, the dynamic head 5.076 in. of water. The mean radius of the discharge orifice was 3 in.

The velocity head, in feet of air, was 37.1. The velocity of the air in the pipe was 48.9 ft per second. From this we calculate that 19.1 cu. m of air were moved per minute.

ANALYSIS OF MATERIALS.

Constituents.	Scrap.	Pig Iron.
Silicon	2.12	2.50
Graphitic carbon	2.65	4.19
Combined carbon	0.55	0.25
Total carbon	3.20	4.44
Manganese	0.45	0.550
Sulphur	0.066	0.030

	Calculated Constituents of the Charged Metal.	Composition of the Cast Iron as Analyzed.	Loss or Gain.
Silicon	2.24	2.30	+ 0.06
Graphitic carbon	3.16	2.35	— 0.81
Combined carbon	.45	0.60	+ 0.15
Total carbon	3.61	2.95	— 0.66
Manganese	0.61	0.55	— 0.06
Phosphorus	0.303	0.39	+ 0.087
Sulphur	0.052	0.033	— 0.019

The coke:

Total carbon	89.5
Sulphur	0.196
Phosphorus	0.005
Ash	10.43
Calories, per kilogram	7129

The ash of the coke consisted of:

Silicon dioxide	49.04
Ferric oxide	29.46
Alumina	8.46
Calcium oxide	4.65
Magnesium oxide	3.21
Sulphur	0.94
Phosphorus	0.50

The analysis of the limestone was:

Silicon dioxide	0.24
Ferric oxide	0.88
Aluminum trioxide	0.27
Calcium oxide	30.60
Magnesium oxide	21.25
Sulphur	0.00
Phosphorus	0.00
Carbon dioxide	47.18

The analysis of the slag was:

Silicon dioxide	51.67
Ferric oxide	12.59
Metallic iron	7.50
Aluminium trioxide	1.35
Magnesic oxide	8.92
Calcium oxide	12.76
Magnesium oxide	5.23
Sulphur trioxide	0.44
Phosphorus pentoxide	0.00

Calculation of calories developed

The coke's calorific value was determined in the Mahler bomb calorimeter and found to be 7129 calories per kilogram. Coke used, 240 — 53 = 187 kg. Hence, 7129 × 187 = 1,333,100 calories.

Silicon dioxide reduced to silicon 0.0206 × 1090 × 7407 = 4844 calories absorbed. Carbon to carbon dioxide, 0.0066 × 1090 × 8080 = 58,127 calories

Total calories:

Coke	1,333,100
Silicon of iron supplied with	4,844
Carbon of iron	58,127
	1,386,383

The escaping gases

Total volume, 1280 cubic feet

Carbon dioxide	12	Volume 179 cu M. Wt. 139 kg
Carbon monoxide	0	Volume 110.2 cu M. Wt.
Oxygen	0.0	
Nitrogen	77.0	

Calculation of calories utilized:

(*a*) TO MELT THE IRON AND SUPERHEAT TO 1900° C.

Weight of iron, 1090 kg.

Specific heat, 0.1124 solid; 0.22 liquid.

Melting point, 1200° C.

Heat of fusion, 69 calories per kilogram.

To raise to melting point:

$$0.1124 \times 1090 \times 1200 = 147{,}030 \text{ calories.}$$

To fuse the iron:

$$69 \times 1090 = 75{,}210 \text{ calories.}$$

To superheat to 1900° C.:

$$022 \times 700 \times 1090 = 167{,}860 \text{ calories.}$$

Total calories in iron, 390,100.

(*b*) CALORIES OF SENSIBLE HEAT IN ESCAPING GASES.

Average temperature of air, escaping from cupola 800° C.

Mean specific heat at 800° = 3246.

Volume of air per minute = 19.1 cu. m.

Duration of heating, 67 minutes.

$$800 \times 0.3246 \times 19.0 \times 67 = 332{,}350 \text{ calories.}$$

(*c*) CALORIES OF LATENT HEAT IN ESCAPING GASES.

9.0 per cent of carbon monoxide.

Total volume of gases, measured at 15° C., and 760 mm pressure, 1280 cu. m.

$$1280 \times 9.0 \div 100 = 115.2 \text{ cu. m of carbon monoxide.}$$

Carbon monoxide weighs 1.2499 kg per cubic meter.

$$115.2 \times 1.2499 = 143.98 \text{ kg.}$$

Carbon monoxide burning to carbon dioxide gives 2410 calories per kilogram; hence, $143.98 \times 2410 = 347{,}010$ calories.

Total heat in gases, $332{,}350 + 347{,}010 = 679{,}360$ calories.

(*d*) CALORIES UTILIZED IN SLAG FORMATION.

70.0 kg of limestone decomposed.

119.5 kg of slag formed.

To decompose limestone:

$$167.68 \times 70 = 11{,}737.6 \text{ calories.}$$

To form slag:

$$550 \times 119.5 = 65{,}725 \text{ calories.}$$

Total heat for slag:

$$65{,}725 + 11{,}737.6 = 77{,}462.6 \text{ calories.}$$

(*e*) HEAT UTILIZED IN HEATING UP CUPOLA.

Inner diameter, 0.56 m.

Height of pyrometer, 2.0 m.

Thickness of brick, 0.11 m.

0.835 sq. m are of brick lining of the cupola.

Average temperature, 700° C.

$$2 \times 0.235 = 0.47 \text{ cu. m of brick heated.}$$

Specific heat, 0.26; specific gravity, 2.2; hence, $0.47 \times 1.00 \times 2.2 \times 9.26 \times 700 = 188{,}190$ calories.

(*f*) HEAT UTILIZED IN HEATING UNBURNED COKE.

Amount of coke, 93.0 kg.

To heat to 250° C. we have, $93 \times 0.201 \times 250 = 4673$ calories.

To heat from 250° C. up to 1900° C. we have, $93 \times 0.2337 \times 1650 = 35{,}861$ calories.

Total, 40,534 calories.

Summary of calories utilized:

	Per cent of total.
(*a*) To melt and superheat iron 390,100	28.14 per cent.
(*b* and *c*) To heat gases and as CO 679,360	49.00 "
(*d*) To form and heat slag 77,462.6	5.60 "
(*e*) To heat cupola 189,658	13.69 "
(*f*) To heat unburned coke 40,534	2.90 "
(*g*) Lost by radiation and convection 8,00	0.58 "
(Estimated from results by Andrews.)	
Total calories accounted for, 1,385,044.6	99.82 "
Calculated calories, 1,386,383	100.00 "
Unaccounted for 1,339	0.18 "

We expect the calories unaccounted for to usually be greater than this, as the methods employed are not accurate to this degree. In this experiment there must be counter-balancing errors which give us this small percentage of heat unaccounted for.

The experiment noted above was performed primarily to secure data on the utilization of the heat developed during melting. The results secured in this experiment are somewhat different from those previously reported.

In the experiment previously reported all of the items were not accounted for as closely as they are in this one and the loss by radiation was taken by difference instead of by direct determination. In this set of data we note that the heat applied to the iron is about 28 per cent of the total heat developed. This high percentage is undoubtedly due to the short duration of the melting.

In the original data from which the foregoing calculations are made we find that the temperatures of the escaping gases during the first part of the melting are very much lower than during the latter portion of the melting. The percentage of carbon monoxide is also greater toward the conclusion than at the beginning. We usually find that during the first part of the melting, when charging is going on and when the cupola is full of metal, nearly to the charging door, the temperature of the escaping gases will not rise much above 750° C., while as soon as the charging ceases and the metal commences to descend in the cupola, the temperature will rise to about 1000° C. and the percentage of carbon monoxide will be about three times what it was at the beginning of the heat. Another considerable percentage of the heat in the present experiment was utilized in heating the foundry cupola. This percentage would, of course, be very much diminished in a heat of longer duration.

The items mentioned, the heat in the gas and that needed to heat the cupola, amount to over 50 per cent of the total.

The percentage of the heat in this experiment, found to be applied directly to the iron, is about the same as that commonly ascribed. Thus, Richards, in his metallurgical calculations, assumes that 32 per cent of the total heat is applied to the iron, but does not state how this figure is derived. The efficiency of the cupola in our experiment, calculated in the usual way, would be 28 per cent.

It seems to me, however, that calculating in this way is somewhat inaccurate, as in melting in any furnace, the furnace itself has to be heated, slag is to be formed and heated and these items, at least, should be credited to the efficiency of the furnace.

Aside from the thermochemical data here presented, there are seemingly some other items of interest. For example, the change in composition of the metal on remelting.

Comparing the changes noted in this paper, with some previously published, we find that there are some differences. Probably the earliest account of the influence of remelting is found in Turner's Iron (The Metallurgy of), in which he reviews some work done in 1853 and quotes the analyses of this metal as obtained by himself in 1886.

The table of his analyses, together with his comments on the same, is given below.

No. of Melting.	Total Carbon.	Combined.	Silicon.	Sulphur.	Manganese.	Phosphorus.
1	2.67	0.25	4.22	0.03	1.75	0.47
8	2.97	0.08	3.21	0.05	0.58	0.53
12	2.94	0.85	2.52	0.11	0.33	0.55
14	2.98	1.31	2.18	0.13	0.23	0.56
15	2.87	1.75	1.95	0.16	0.17	0.58
16	2.88	...	1.88	0.20	0.12	0.61
18	...	2.20	...	...	...	...

"It will be noticed that, owing to the oxidizing effect of remelting, the proportion of silicon steadily diminished, while sulphur was at the same time absorbed from the furnace gases. The natural effect due to these changes was produced upon the condition of the carbon, which, instead of being almost wholly graphitic, became nearly all combined, thus producing a hard, white iron, which was deficient in tenacity, and brittle.

"The elimination of manganese with the silicon, the increase in the percentage of phosphorus due to its concentration in a smaller quantity of metal, and the initial increase of total carbon for a similar reason, are all in accordance with what is observed whenever iron is melted in the air, and when the resulting slag is not strongly basic."

The results just given were obtained by melting the metal in an air furnace. Turner then quotes some other data obtained by melting in a foundry cupola. I quote his comments and analyses.

"In ordinary practice a cupola is employed. Here the oxidation is greater, while as the iron melts in contact with the fuel it more readily absorbs sulphur. As a consequence, though the changes which take place are of the same kind, and follow the same order as that previously given, the effect of each melting is more marked." This is illustrated by the following analyses, from experiments conducted by Jungst in the Imperial Foundry at Gleiwitz:

	1st Melting.	2d Melting.	3d Melting.
Carbon, graphitic	2.73	2.54	2.08
Carbon, combined	.66	.80	1.28
Silicon	2.42	1.88	1.16
Sulphur	.04	.10	.20
Phosphorus	.31	.30	.28
Manganese	1.09	.44	.36

In "General Foundry Practice," McWilliam and Longmuir say: "In remelting an ordinary gray iron mixture there is, as a rule, a loss of about 0.2 to 0.3 per cent of silicon. Unless the total carbon be abnormal, this will not change much; but, if abnormally low, it will tend to increase to a normal amount by reason of contact with the coke, and hence very low carbon mixtures cannot be successfully melted in the cupola; a good reason why the melting of steel-casting mixtures in the cupola, as has been attempted by more than one firm, has not met with success. The manganese will decrease to a variable extent, 0.2 to 0.3, representing a typical loss if about 1 per cent is present in the charge, while with a low manganese content (like 0.3 per cent) the loss may be almost nil. The phosphorus comes out practically according to calculation; while the sulphur, again, owing to contact with the fuel, will be found to have increased, an increase seldom less than 0.02 per cent, unless with exceptionally pure coke or with a charge initially high in manganese, the manganese in the latter case apparently combining with the sulphur in the metal and taking it into the slag."

Hoffman, in his "Iron and Steel," quotes some results published by Beckert on the influence of remelting.

Hoffman's statements and the analyses by Beckert we quote as follows:

"Every melting of a metal is connected with loss. In melting down cast iron in a furnace, the components would be more or less oxidized by the action of CO_2 in the order of their affinity to O, viz: Mn first, then Si, C, and Fe, were it not that iron predominated strongly over the other elements, and protecting them entered to a considerable extent into the slag, where it is found in larger amounts than Mn and Si. Beckert illustrates by subjoined table the change cast iron may undergo by re melting four times.

Melt.	Before.	After first	After second.	After third	After fourth
C.	2.154	3.682	3.641	3.606	3.463
Si.	2.096	1.846	1.688	1.610	1.549
Mn.	0.768	0.537	0.441	0.336	0.105

From the references quoted, we note that there is a silicon loss, a gain of combined carbon and a loss of graphitic carbon, these taken together give a loss of total carbon on each remelting.

There is also noted a gain of sulphur. The statement is usually made that all of these two later elements present in the metal charge will be found after melting as constituents of the cast iron.

In this our own experiment as well as in several others which we have conducted, the results of which as yet are not quite ready for publication, we find either no loss of silicon or a slight gain; that there is only a slight gain of phosphorus, and that the sulphur also shows no increase.

I ascribe these effects to the slag which we always endeavor to have present. Its composition is given along with the analyses of materials.

We are carrying on other experiments along these lines upon which we hope to report from time to time.

Armour Institute of Technology,
Chicago, Ill.

The Construction of Gas Producers.

By Dr. Oskar Nagel.

We distinguish two fundamental types of producers.

The first and oldest has been developed from the blast furnace and is a vertical shaft in which the fuel moves downward, while the air and the gas travel in the opposite way. The gas formed passes through the green fuel, carrying along water and volatile matters. The shaft is built of firebricks and surrounded by a wrought-iron shell. The tops of the producers are sometimes made of an arch of firebricks, but frequently only provided with

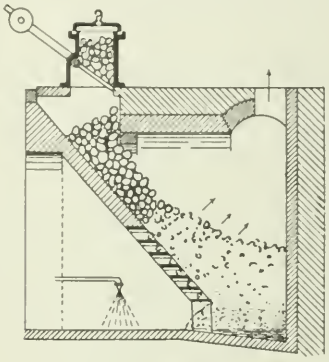


FIG. 1.—SIEMENS PRODUCER

water-cooled covers made of iron. Cast steel is also sometimes used for the parts that are exposed to considerable heat. The shaft is generally circular, sometimes, however, square. The walls are mostly vertical, sometimes showing wider and narrower portions, as will be seen from the illustrations.

Fixed rules as to the interior shape cannot be given, different fuels requiring a different treatment. The main consideration must be to provide for the increase of volume of certain coals during the period of distillation; for this reason the shaft is enlarged down to the zone of reduction. The walls near this zone should be vertical so as to prevent, as far as possible, the slag from sticking. At the bottom end the shaft

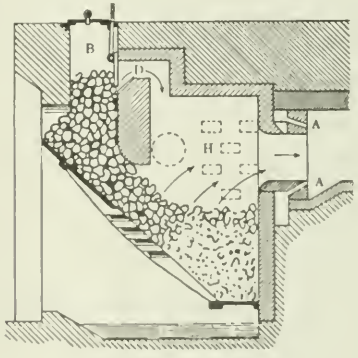


FIG. 2.—"HALF-GAS FIRING."

is frequently made narrower in order to force the air straight upward, instead of along the side walls. Such a narrowing will never do any harm, as at this point the volume of the fuel is already considerably decreased by the partial combustion. Vertical walls facilitate uniform downward travel of fuel.

Poke holes are generally provided in the cover and in the side walls, in order to make it possible for the fireman to reach the interior layers of fuel and to break up the clinker.

Since in a vertical shaft the fuel is easily kept at uniform height, the shaft producer is used to-day *almost* exclusively,

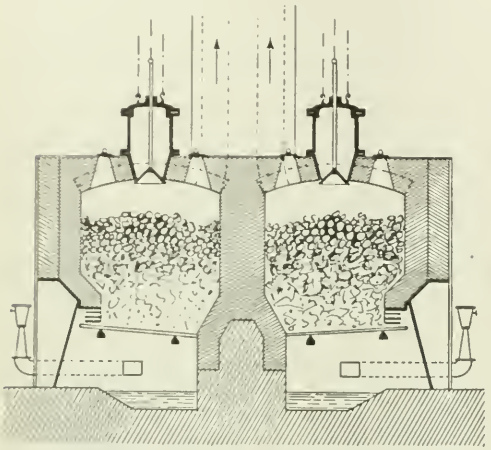


FIG. 3.—MODIFIED SIEMENS PRODUCER.

but *always* in cases where the producer plant is not directly connected to the furnace.

The second type, which was developed by Siemens, is used when producer and furnace are built in one unit (Fig. 1). The fuel is charged through a hopper provided at the top and passes over an inclined firebrick wall, which, at the bottom is continued as a stepgrade.

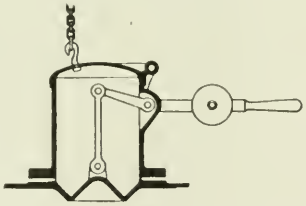


FIG. 4.—HOPPER.

The Siemens type of producer offers less resistance to the passage of the gas through the fuel bed than the shaft type, as in the latter the gas has to travel through the entire height of the coal contained in the producer. For this reason blowers are used in producers of the shaft type, while in Siemens producers in many cases natural draft, produced by a stack behind the furnace, is employed; this, however, frequently necessitates a reduction of the fuel layer and thereby causes incomplete gasification.

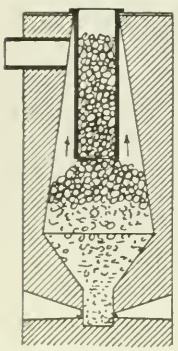


FIG. 5.—EBELMAN METHOD.

The loss produced by the last-mentioned fact is not very considerable, as the gas produced is directly and immediately used and pretty nearly all the heat passing from the producer to the furnace utilized. If, on the other hand, the gas would be cooled before being used, very considerable losses (up to 40 per cent or 50 per cent) would result. Therefore, shortly after the introduction of the Siemens producers addition of water was employed by arranging a water pan in the ash pit and producing the steam by the radiating heat.

Within the class of Siemens producers we must also include the so-called "half-gas firings," which are especially used for low-grade fuels. These firings are not supposed to produce complete gasification. The gas produced contains much carbon dioxide. For utilizing the monoxide, an additional supply of air is introduced in the combustion place.

In the charging hopper *B* (Fig. 2) tarry gases and steam are

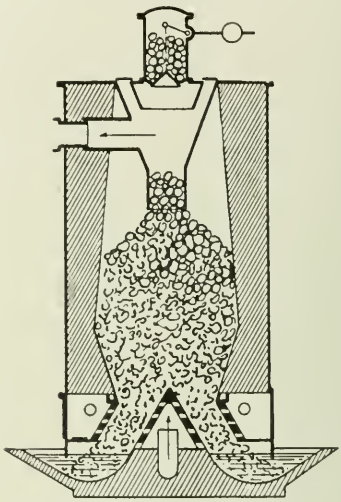


FIG. 6.—BUIRE-LENCANCHEZ PRODUCER.

produced by dry distillation. In order to prevent them from escaping during the charging of fuel, connecting channels *D* are provided between the producer *H* and the hopper. These channels are frequently provided with a movable slide. The secondary combustion air enters through tuyeres *A* after being preheated in the brickwork. It is a disadvantage that these producers depend on the chimney draft, because the latter is governed by atmospheric conditions. Hence, even in these producers artificial blast has been resorted to, which permits the use of a higher fuel bed. Fig. 3 shows this new development of the Siemens producer (four producers combined to one unit), which is very similar to the shaft type.

The use of an artificial blast for producers is almost uni-

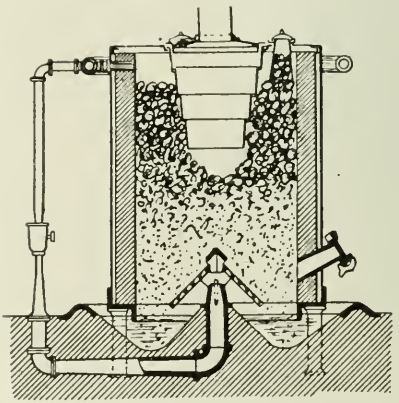


FIG. 7.—ZETZSCHE PRODUCER.

versal for heating purposes; however, considering the generation of power we find an exception in the so-called suction-gas producer plants. Here the sucking power of the piston of the gas engine is utilized for drawing the air through the producer,

the quality of gas produced being automatically regulated by the demand of the engine. As the sucking power of the latter

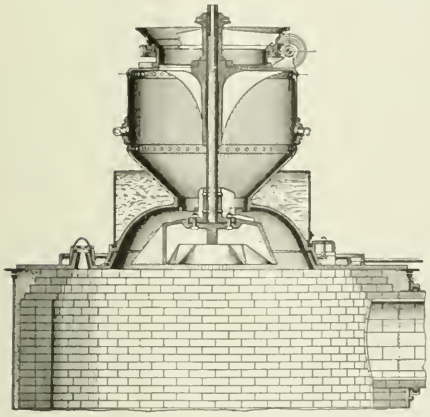


FIG. 8.—BILDT FEED.

is very large, the difficulties met with in producers with natural draft do not arise in this case.

The aim in the development of the construction of modern producers is the reduction of manual work, the production of a uniformly good gas with high efficiency, and, if possible, by a continuous operation of the producer.

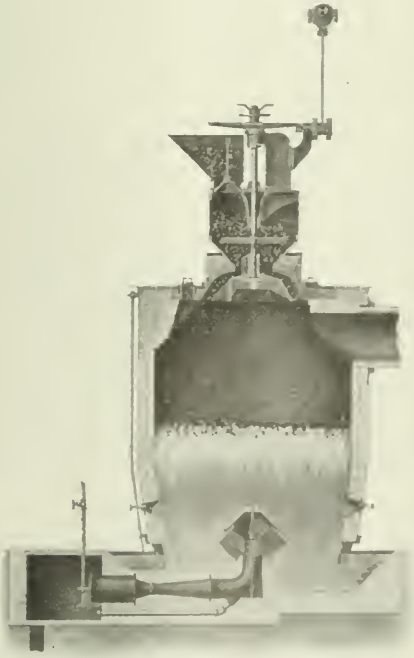


FIG. 9.—WATER-SEAL PRODUCER WITH BELL FEED.

The latter point is especially desirable with installations containing only one producer, while in plants comprising a number of producers an alternate disconnection for cleaning purposes is possible. If one main is supplied from several producers, the uniformity of the gas is increased.

The charging appliances of gas producers must be so arranged that the production of gas is not interfered with during the operation of charging. Hence, in producers of the draft and suction type the entrance of air has to be prevented; in pressure producers the escape of gas. This is effected by bell hoppers.

In all these hoppers the fuel to be charged is first transported to a hopper space, which is separated from the producer space proper by an air-tight bell. Then the upper door of the hopper space is closed and by opening the bell the charge is allowed to run into the producer. Fig. 4 shows such a hopper. The charging is done at certain intervals, which causes a change in the uniformity of the gas, as the dry distillation of

FIG. 10.—MORGAN PRODUCER.

the green coal is not going on uniformly. Wendt observed charges of more than 10 per cent in the thermal value of the gas when working with a producer charged with coal rich in gas. The harder the fuel, the smaller are the variations.

In order to produce a more uniform gas and to reduce the manual work, continuous charging has been tried by various ways.

The first, suggested by Ebelman, Fig. 5, in the first half of the nineteenth century, consists of the application of a charging shaft, from which the fuel gradually travels to the zone of combustion. The gas is drawn off outside the charging shaft whereby the latter assumes the temperature of the escaping gas. This causes the generation of gas already in the shaft and makes the use of a bell hopper (Fig. 4) unavoidable, except in cases where still larger quantities of fuel are kept in readiness above the charging shaft. The latter is generally made of cast iron, and is gradually destroyed if exposed to high temperatures.

In the producer of Buire-Lencanchez (Fig. 6) the gases escape through the charging shaft.

In the producer of Böringer the fuel is charged outside around the central pipe, which serves only as gas escape.

Zetzsche has gone still further (Fig. 7) by so developing this central pipe that it can be lengthened or shortened, whereby the height of the fuel bed can be regulated according to the quality of the fuel. The lower rings of the pipe can be easily exchanged if necessary.

A second method of charging continuously employs various mechanical appliances, the first among them having been con-

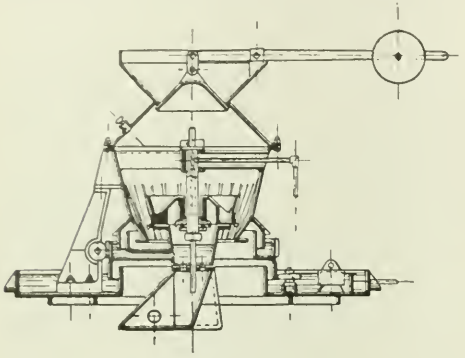


FIG. 11.—POETTER PRODUCER.

structed by Bildt (Fig. 8). A water-seal producer with Bildt feed is shown in Fig. 9.

To-day there is a considerable number of mechanical charging devices on the market. The Morgan feeder, of the Morgan Construction Company, of this country, the automatic feed of which is stated to insure almost absolute uniformity of both quantity and quality of gas produced, is shown in Figs. 10 and 20; the feeders of Poetter & Company in Figs. 11 and 12.

The Poetter producer is not provided with a double-door hopper. However, it is recommended to make an air-tight pipe connection from the hopper to the coal storage. By opening a slide the desired quantity of fuel is allowed to run into the hopper. This feed can also be made absolutely mechanical. Those parts of the feed which come in contact with the hot gases are generally water cooled. A distributor takes care of

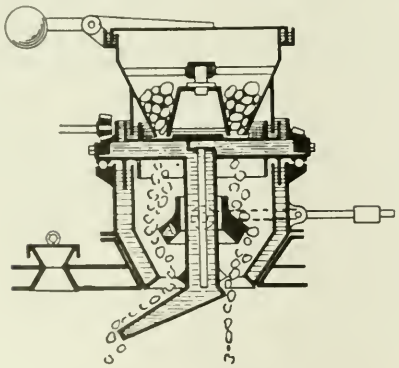


FIG. 12.—POETTER PRODUCER.

the uniform distribution of the fuel. This feature makes these constructions superior to the plain bell hoppers. However, the mechanical feed is used only for large units.

While with all producers it is of advantage to use a fuel of uniform size, this is especially important in producers which are charged mechanically. Poetter has constructed a feed for coarse coal in which he provides a crusher above the distributor.

It must not be overlooked, however, that considerable quantities of dust are produced by the action of these crushers.

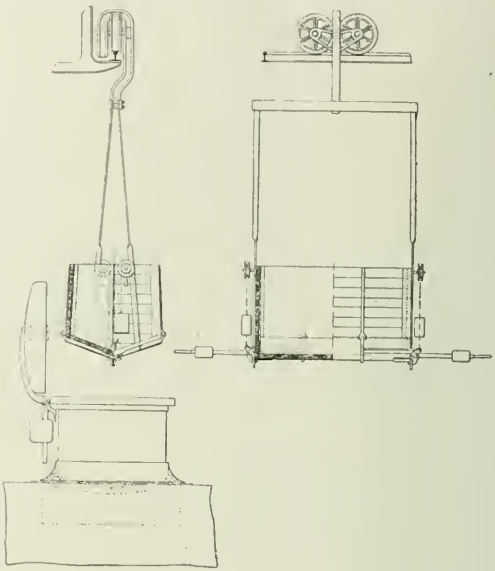


FIG. 13.—CHARGING DEVICE FOR RUSSIAN WOOD PRODUCERS.

This causes an increase of the impurities of the gas, a tight packing of the fuel and finally the formation of holes.

A charging device for Russian wood producers is shown in Fig. 13.

Another important part of the producer is the means for removing the ash and clinker. Here the aim is also to reduce the manual work and to decrease the loss of combustibles through the ash. In the old Siemens producers up to 10 per cent of the fuel was found in the ash, later producers showed a loss of 5 per cent, while in modern producers the loss is said to be reduced to 1 per cent or 1½ per cent. Further aims are the removal of clinker without discontinuing the operation of the producer and accessibility of its respective parts.

FIG. 14.—KOERTING BLOWER.

We will now say a few words regarding the blast, which is produced in all, or nearly all, plants by means of steam jet blowers, which are the most convenient appliances to that end, as they do not get out of order; furthermore, every producer is, and remains, independent with respect to the blast if the latter is produced by steam jet blowers. (For very wet fuels,

as certain grades of peat and lignite, dry blast has to be used, as is easily understood.) The steam jet blower must be properly constructed in order to produce economically the highest possible steam velocity.

Fig. 14 shows the well-known Koerting blower with spindle. *A* is the air inlet, *R* the regulating spindle, *S* the steam connection, *M* the nozzles. With ordinary bituminous or hard coals there is no difficulty to so regulate the quantity of air by means of the steam jet blower as to get dry gas. It is hardly necessary to lay stress upon the self-evident fact that the steam used in these blowers should be dry.

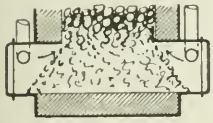


FIG. 15.—ASH-PIT.

A high-pressure blast is of no advantage in the operation of producers, as it means an unnecessary loss of energy, formation of holes and deterioration of the gas.

Returning again to the discussion of the ash-pit region, we show in Fig. 15 the ash pit of a producer without a grate. The ash rests upon a firebrick base, the air enters through the sides as shown by the arrows. In a vertical producer of considerable diameter the air will rise along the wall, the path of least resistance, whereby a dead zone is formed in the center of the shaft, causing a defective production of gas. Therefore, in large producers the diameter is frequently decreased toward the bottom.

The simple plane grate insures a uniform distribution of the air over the entire area. However, with large diameters the life of the grate is short and the removing of the clinkers a very tedious and difficult operation. Furthermore, the unburned fuel falling through these grate bars represents a considerable loss.

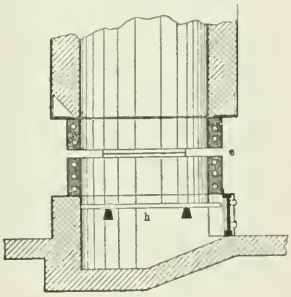


FIG. 16.—TURK'S PRODUCER.

For facilitating the removing of the clinkers in large producers, so-called "false grates" have been resorted to, which at the period of cleansing are inserted above the ashes. In this case the gas production is stopped during cleaning. Turk's producer, which is illustrated in Fig 16, shows in slit *c* the place where the false grate is inserted above the grate *h*.

Step grates are also sometimes employed. Fig. 17 shows such an arrangement in a Turk producer. Fig. 18 illustrates a Poetter producer with so-called polygonal grate. The removal of the clinker from these producers is by no means an easy job. The loss through fuel getting into the ash is 5 per cent to 6 per cent.

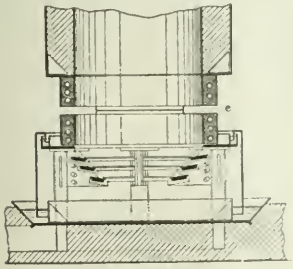


FIG. 17.—TURK PRODUCER.

Of similar construction is the producer with basket-shaped grate, which is built by Paul Schmidt and Desgras. It is mainly used for lignite briquettes. The channels for the admission of air also support the circular lower grade beam. The ashes rest in most of these constructions upon the bottom of the ash pit, which is covered with water. Sometimes also plane grates are used at the lowest point of the grate region. The Mond producer shows a similar construction around the grate.

In all these producers the clinker accumulations formed must be loosened through the grate slits. Hence the various parts have to be removable and exchangeable. In order to facilitate the removal of the clinkers, Schneefuss has proposed a shaking grate of basket shape suspended on chains.

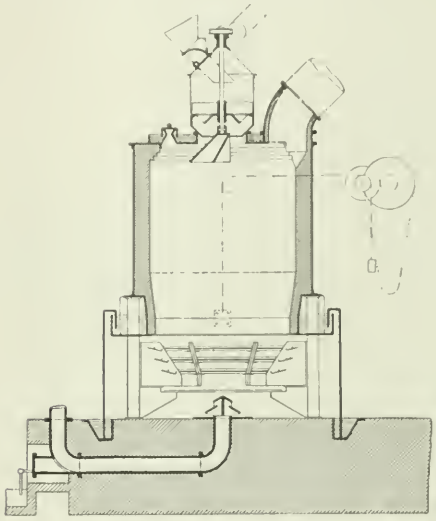


FIG. 18.—POETTER PRODUCER.

During the period of removing the clinkers, the operation must be interrupted in all these producers, as the ash doors have to be opened.

If the operation of the producers is to be continuous, the ashes and clinkers must be removed during the operation. This

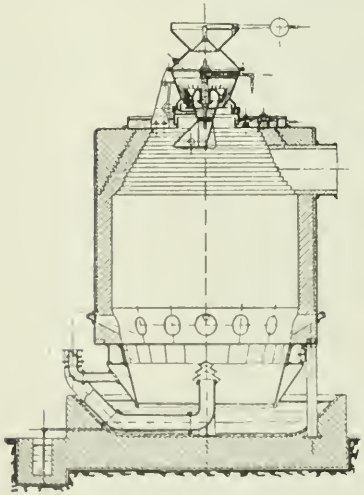


FIG. 19.—PRODUCER, WITH WATER SEAL.

is effected either by a water-seal or by mechanical draft appliances. A typical producer with water seal as constructed by Poetter & Company is shown in Fig. 19. The combustion air is introduced through a central pipe The hot bed of ashes effects a posterior combustion of carbon particles which might have escaped combustion and better distribution of the air.

In the Morgan producer (Fig. 20), which gives excellent results—the loss of fuel in the ash being reduced to 1 per cent to

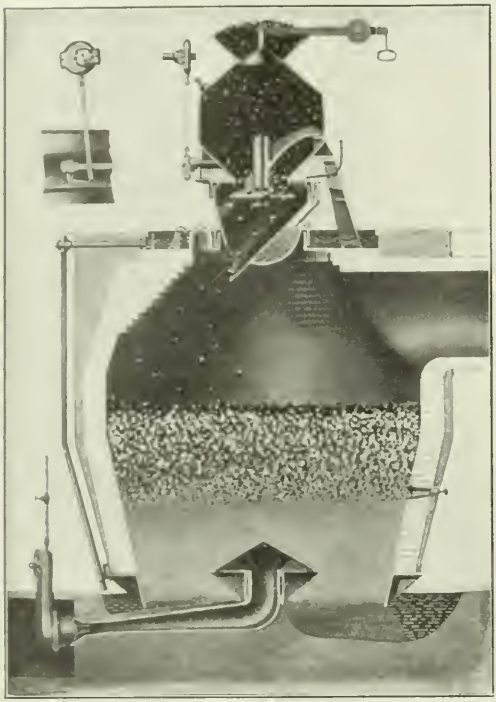


FIG. 20.—MORGAN PRODUCER.

1½ per cent—the air is introduced in the center, while Schlueter (Fig. 21) arrives at good results by introducing air at the sides through a certain number of tuyeres and by suitably re-

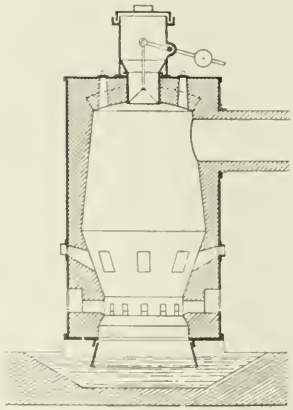


FIG. 21.—SCHLUETER PRODUCER.

ducing the diameter of the producer in the zone of combustion.

As part of the water of the seal is evaporated by the heat of the ash, the quantity of water (steam) put into these producers must be reduced. The clinkers are loosened by poke-holes in the walls. A producer of remarkable simplicity in which the removal of ash and clinkers is easily performed is the Duff process, which in the Bradley modification is shown in Fig. 22.

The special feature of this producer is the use of four blowers and four grates. It is to be stated that, while only two

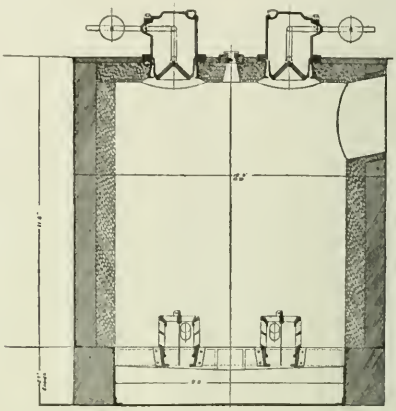


FIG. 22.—BRADLEY-DUFF PRODUCER.

grates are shown in the cut, a dividing plate is provided between each grate. This makes practically four independent grates. For instance, should the fire get too hot at either of the end walls running parallel with the grate, the blowers controlling those halves of the grates are closed down partly or entirely, as the case may require. This applies also to the center halves of the grates, which are controlled and regulated in the same manner. Hence, an excellent control of the condition of the fire is effected by the regulation of the steam and air blast.

For the removal of ashes mechanical arrangements have also

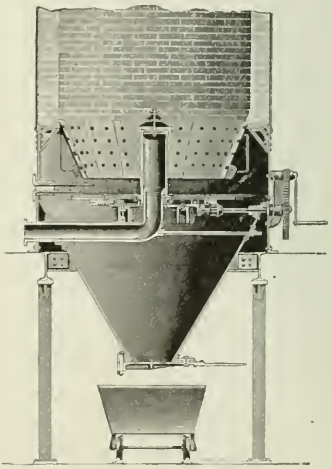


FIG. 23.—TAYLOR PRODUCER.

been constructed. The Taylor producer (Fig. 23) was among the first of this kind. In this type a solid circular bottom plate or table carries a deep bed of ashes and is arranged to revolve; the revolving of this table discharges the ash and clinker over the edge into a sealed ash pit beneath. The table is revolved

by means of a rack under the table, engaging with a pinion on a shaft driven by hand or power gearing substantially attached to the outside of the lower casing. Suitable guides hold the table carefully. The grinding is done as fast as the ashes rise too far above the desired line—say, every 6 to 24 hours, or according to the rate of working. The bed of ash is kept about 3½ ft. deep on the revolving table in the larger sizes.

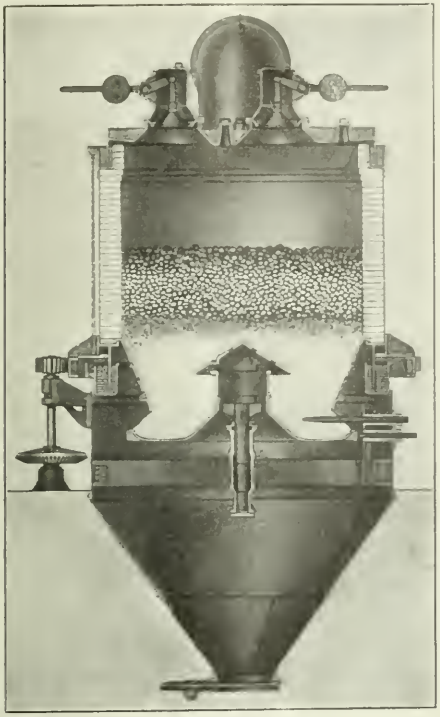


FIG. 24.—HUGHES PRODUCER.

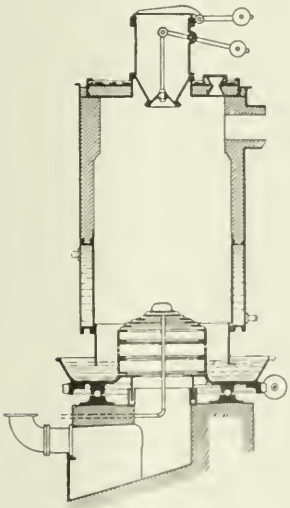


FIG. 25.—KERPELY PRODUCER.

Another example of a self-cleaning continuous producer is the Hughes type, shown in Fig. 24. This producer is divided into two parts, the upper and the lower, with a water seal between, the upper portion rotating mechanically. By means of an iron bar, thrust between the ash table and the revolving part of the body, the clinkers are broken up and with the ashes fall into the ash receptacle beneath. By opening an outlet valve at the bottom of this cone-shaped ash receptacle the ashes are discharged into cars underneath.

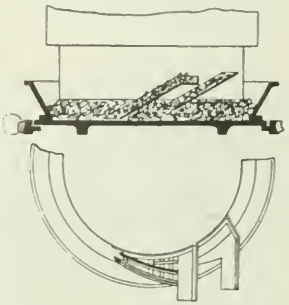


FIG. 26.—ASH REMOVAL.

The upper shell of the producer is made of steel plate riveted to and resting upon a steel ring forming a combined tread and rack. This rack is driven by a vertical shaft and pinion, connected to the main driving shaft by a train of gearing. Thus the upper shell is rotated as above mentioned. The tread of this steel rack travels on conical chilled-iron wheels having tight axles revolving in self-oiling boxes.

A further development as far as the rotation of the grate parts is concerned is the Kerpely producer, shown in Fig. 25. The rotating plate is developed as water seal and carries the grate, which consists of several plates, through which the air passes into the producer. The lower part of the grate disintegrates the clinkers and the latter are automatically removed from the water seal by means of a shovel. One rotation is made in three hours.

In the Rehmann producer the rotating part consists of suitably arranged cones, which are provided with perforations through which the air enters. The arrangement of the shovels for removing the ash is shown in Fig. 26. The larger pieces of clinkers are raked out, the smaller ones shoveled out.

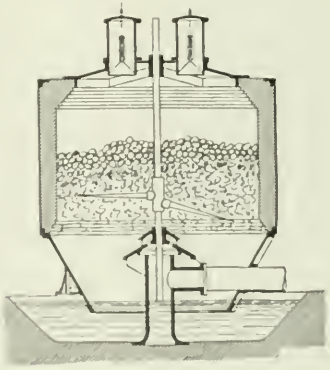


FIG. 27.—FRASER-TALBOT PRODUCER.

In these producers the ash is loosened and the clinker disintegrated. We will now discuss the next step—the mechanically poked producers.

The Fraser-Talbot producer (Fig. 27) pokes the fuel by means of two agitators arranged on a vertical shaft.

The latest development along these lines is the Hughes producer (Fig. 28), in which the mechanical poker is a water-

cooled steel casting suspended from a trunnion. The poker is operated by ratchet gearing actuated by a crank and crankshaft which is driven by a reduction gearing connected to the main shaft. This mechanism moves the poker back and forth, agitating and breaking up the mass of fuel and evenly distributes the coal and helps in working down the ashes for removal. The uniform treatment secured by the mechanical poker gives better and more uniform results as to quality, quantity and supply of gas, and reduces the cost of installa-

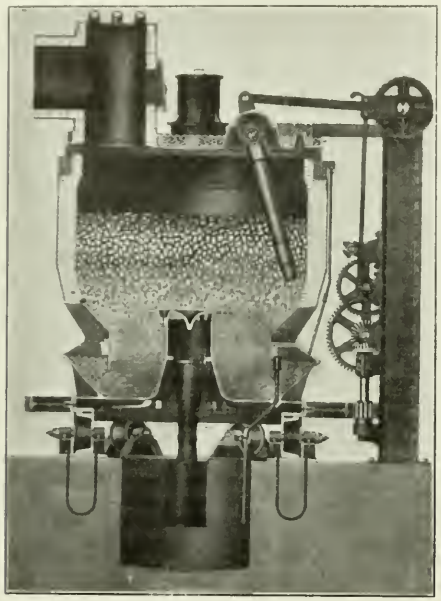


FIG. 28.—HUGHES PRODUCER.

tion and operation. The power required to operate a single producer is .3 electric hp. Twenty five pounds of coal are gasified per square foot.

Another way for the removal of clinkers is Blesinger's device, shown in Fig. 29. In this type so-called grate cars are used for receiving ash and clinkers.

For preventing the formation of clinkers on the walls of the producer, water cooling is applied more or less successfully. In order to prevent the formation of smoke during poking, the device shown in Fig 30 is successfully used. When the lid of a poke hole is opened, a steam cock is simultaneously opened in the turning point, steam flows over the poke hole from these points, which prevents the escape of gas.

Furnace Electrode Losses.

By Carl. Hering.

It would probably surprise many who have not calculated or measured the power lost in the electrodes of electrical furnaces, to find how large it often is, and in the construction of such furnaces the question which concerns the engineer who proportions and designs the electrodes, naturally is, can this loss be reduced, and if so, how much and in what way. In many cases the chief question in the commercial success of a proposed furnace operation is the cost of the power, or more briefly "does it pay" In some of these cases a saving of a part of these large losses in the electrodes might be enough to turn the tables, when the cost of the power is the criterion. In other cases, to the writer's knowledge, large sums of money might be saved annually by a closer approach to the best proportions of the electrodes.

It, therefore, is becoming a matter of considerable importance now to know the laws underlying the proper design of electrodes in order to realize the best proportions if it is possible and practicable, or if it is not, then at least to know how to approach them as closely as the circumstances will permit. It may often be the case that the theoretically ideal design cannot be realized, and in some cases the cost may be prohibitive;

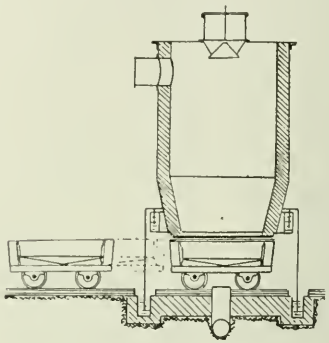


FIG. 29.—REMOVAL OF CLINKERS.

it then becomes the duty of the engineer to work out the usual problem of the limit to which an approach to the ideal conditions should be carried, or in other words, the conditions of least total cost.

It is evident that this becomes possible only when the ideal conditions are known. As long as they are not known, the designing of electrodes becomes a process of "cut and try" or in other words, more or less intelligent guessing. This process of groping around in the dark is often expensive, generally it is slow and often it is unsatisfactory, as one may be going all around the mark while being quite near it. Experiments made without a knowledge of the laws governing electrodes may give very misleading results, or the results may be improperly interpreted, or the generally dangerous process of exterpolating may lead one off the right track and to quite incorrect conclusions.

From the almost complete lack of information on this subject in text hooks and current literature, as also from the way in which the experimental researches have been conducted, it appears that the laws concerning the proper proportioning of such electrodes and the minimum possible losses in them, had not been determined. The writer, therefore, undertook the determination of them by an accurate and rigid analysis based

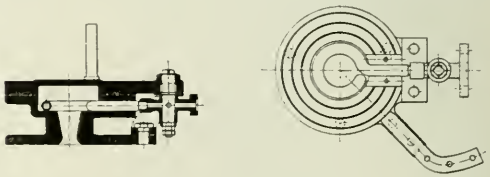


FIG. 30.—PREVENTION OF SMOKE.

on the fundamental laws of heat. The results are of considerable interest and in some respects quite surprising, as they reveal some very unsuspected relations which are of considerable importance in practice and some of which would not be likely to be accepted if it were not the fact that they can be demonstrated by a rigid analysis. They show that in some prominent cases the proportioning of the electrodes have been wide of the mark, and it is not an exaggeration to say that large sums of money could in some cases be saved annually

by changes in the electrodes, some of which are readily made while others involve more radical reconstructing. A very satisfactory result is that in many cases the ideal conditions are not hopelessly distant, but could readily be realized. The results were a good illustration of the great utility of a purely theoretical analysis, in pointing out to the designer the right path and the ideal conditions.

It is not the purpose of the present short article to give these results in detail nor the demonstrations, as they are somewhat complicated and involved, and might be improperly applied if not correctly understood. Their complete explanation would require considerable space, and involves the demonstration of a theorem in heat conduction which it is believed had not been made previously, or at least was not generally known. It is furthermore, of course, not possible to determine the best proportions, materials and losses, and to make accurate comparisons and draw definite conclusions from them in particular cases, unless the necessary fundamental physical constants and data are known, among which are the temperatures and the heat and electrical conductivites of the electrode materials at those ranges of temperatures, the heat insulation of the furnace wall surrounding the electrode, etc., which are only crudely known. It is hoped, however, that the knowledge of the correct laws of electrode losses and the importance which the reduction of those losses has in practice, will stimulate the more accurate determination of these important constants.

The writer will, therefore, limit himself here to some general results and to some comparisons and conclusions based on what seem at present to be the most likely values of the physical constants of the usual electrode materials graphite and amorphous carbon. As our present knowledge of these constants is rather crude, especially the absolute value of the heat conductivities at the high temperature ranges of electrical furnaces, the comparisons and conclusions concerning these materials may be altered somewhat when these physical constants become more accurately established.

Some of the general principles underlying the calculations of electrodes are as follows. It is evident that the larger the cross section of an electrode of given length, the greater will be the loss through it by conduction of heat from the furnace, and the less will be the electrical loss due to its resistance. The conditions are reversed when the section is constant and the length is varied. For both extremes the losses become infinite, and as they are finite in practice, there should be some proportions at which they are least.

One material may have a greater heat conductivity and a lower electrical conductivity than another, and these conductivities vary with the ranges of the temperature.

The heat in the furnace and that generated in the electrode due to its electrical resistance both originate electrically, and it is, therefore, immaterial as far as the money value of this loss is concerned whether it is more of the one kind or of the other; the total is all that concerns us here.

If both contribute to this total, how should they be added? It is customary to add them arithmetically, but is this correct?

Does the one loss affect the other?

A high heat conductivity is, as a rule, accompanied by a high electrical conductivity, hence it increases the heat loss and reduces the resistance loss; is this an advantage or otherwise?

What qualities are those which increase or decrease the total loss? Does graphite necessarily chill the furnace, as has so often been claimed, because it conducts heat so well?

Is one material intrinsically better or worse than the other, as far as the loss is concerned?

These and many other questions arise, and a proper analysis based on the fundamental laws of heat should answer them. In how far the conclusions apply to actual furnaces, of course, depends on how far it is possible or practicable to realize in practice the conditions on which the analysis is based.

Some of the general results of this analysis, as far as they concern all materials, are as follows:

For each electrode material there is a minimum total loss depending on the current and the temperature; it is obtained by proportioning the dimensions of the electrodes properly. Whether these best proportions can be carried out depends on the design and conditions of the particular furnace, and must, therefore, be decided by the designer. In most cases it would probably be possible, while in others it would not, in all cases it could be approached. This loss is different for different materials.

Any departure from these proportions increases the loss, hence no possible further changes of proportions can still further diminish it.

These proportions are very different for different materials, hence, if it is not possible to realize them with one material it may be possible to do so with another.

This minimum loss is smaller than is apparently generally supposed and is far less than it is in many existing furnaces. Hence considerable saving of power could be effected in many cases by a mere change of proportions, and in some cases by a change of material.

The usual method of proportioning electrodes on a basis of a fixed current density is quite incorrect and is more apt to lead one away from the desired result than toward it. It is quite as incorrect as it would be to calculate transmission wires for the least practicable loss on a basis of current density.

Comparing different materials experimentally by means of electrodes of the same size is equally incorrect and misleading; it also leads one away from the goal rather than toward it.

It is probably better to arrive at the best proportions by calculation than by experiment, provided the required physical constants are known. It is unquestionably much cheaper, quicker and simpler.

Knowing the rigidly correct relations between the various factors, it becomes possible to calculate these physical constants from the measured results of an existing case; it thus becomes possible to calculate a second design correctly, from the data obtained from a first trial.

The prevalent idea that a high heat conductivity is a very bad property of an electrode material, necessarily causing it to chill the furnace, is in part fallacious. While, of course, a low heat conductivity is in general a desirable quality of an electrode material, yet it may be actually objectionable in that it may make the proportions impracticable. There are conditions, and by no means abnormal ones, under which the writer finds that the lower heat conductivity of carbon makes the best proportions so awkward that it would not be practicable to adopt them, while with graphite with its higher heat conductivity, the proportions are easily realized. There are other cases in which the reverse is true.

Another mistaken idea is the generalization of physicists that a good electrical conductor is necessarily a good heat conductor. While this may be roughly true for the conductivities (that is, the reciprocals of the specific electrical and heat resistances), it is by no means necessarily even roughly correct for the conductances (the reciprocal of resistance as distinguished from specific resistance or resistivity), for as the writer has shown* it is quite possible to so operate an electrode that it becomes in effect a perfect heat insulator (that is, that its heat conductance is zero), although it is at the same time a good electrical conductor, and this is true irrespective of what the heat conductivity of the material may be. Thus a good conducting electrode may become even a better heat insulator than the refractory walls of a furnace. In fact, if it were possible to construct a furnace so that its walls consisted entirely of the electrodes, the curious condition could be realized of a furnace whose heat insulation is absolutely perfect. Just as a good electrical conductor may in effect be made to act as a perfect electrical insulator by means of a counter e. m. f. in the circuit, so the conductance of heat may be checked by something

*See this journal, p. 7, June, 1909. Also Transactions of the American Electrochem. Soc., Vol. XV, p. 1.

analogous in the form of temperature. Whether it is practicable to operate electrodes under these forced conditions, is a matter for the designing engineer to determine.

It is also a mistaken idea that the normal loss necessarily increases in proportion to the temperature, as it does not, if the electrodes are properly proportioned.

Nor does this loss necessarily increase in proportion to the heat conductivity, or diminish in proportion to the electrical conductivity. As a matter of fact, it is smaller with carbon even though its electrical resistivity is considerably greater than that of graphite, if the assumed constants are correct.

The above remarks referred to materials in general. When applied to the specific materials carbon and graphite, the comparative results, of course, depend on what the physical constants of these materials are These have, it appears, never been accurately determined for the ranges of furnace temperatures, but from published experimental data the writer has deduced certain values which are probably not very far from the correct ones. As both carbon and graphite are artificial products, it cannot be expected that these physical properties will be the same in different lots; this is more especially true for carbon whose resistivity seems even to be very different in large electrodes from what it is in small ones, as though the baking had not penetrated to the interior. Hence conclusions based on such data will, of course, also lack accuracy. It may be of interest to say here, however, that the minimum loss in electrodes and their best proportions, do not vary in the same (or inverse) proportion as the two conductivities, but less rapidly, hence a variation or inaccuracy of say 10 per cent in the constants will change the results by less than 10 per cent.

Based on what appear to the writer to be the most probable values of these constants known at present, the following conclusions can be drawn, and it is believed that they will not be very materially altered by subsequent more accurate determinations of the constants.

The prevalent idea that graphite, on account of its higher heat conductivity, chills the furnace, is a mistake, and if it has been found to do so it is because the electrodes were improperly proportioned.

The loss of energy in graphite electrodes for the same furnace conditions (that is, temperature and current) will always be slightly greater than for carbon, when both are properly proportioned to obtain the minimum loss, but the difference is apparently only a few per cent and is therefore far less than the differences in losses due to incorrect proportioning are likely to be: it is certainly not enough to cause a noticeable chilling of the furnace. Hence the choice between carbon and graphite should be based on other considerations such as consumption, size, shape, cost, etc.

The proportions for graphite are very different from those for carbon, when both are designed for obtaining the minimum loss. In many cases the proportions for carbons become impracticable, and if they cannot be carried out the minimum loss cannot be attained, while with graphite they are possible; hence in such cases the loss for carbon could easily exceed that for graphite. The reverse is true in other cases.

Experimental comparisons between carbon and graphite electrodes of the same size are worse than useless, as they give one a false assurance. Either one or the other was then necessarily incorrectly proportioned, and is therefore tested under unfair conditions.

This minimum loss for both carbon and graphite is smaller than is apparently generally believed, and the analysis points out the directions of improvement of the physical properties by which it might be still further reduced.

If carbon electrodes for very high temperature furnaces are proportioned correctly at the start, and if during operation they become graphitized at the hot end, they will then no longer be properly proportioned and the loss will be increased. Or if improperly proportioned at the start the loss after graphitization may be less.

Such experimental data as that given by Mr. C. A. Hansen in his interesting article on Furnace Electrode Losses on p. 358 of the previous issue of this journal, are very valuable to the profession and will aid greatly in developing the proper design of electrodes. His results, as distinguished from his deductions from them, bear out the analytical researches of the writer. If his tests had been carried out with greater precision the results would have enabled the physical constants to be deduced from them. But even as they are, the constants calculated from the results agree as well as could be expected with those that the writer has deduced from other sources.

In making his deductions, however, Mr. Hansen has in some cases resorted to the always dangerous process of exterpolation or generalization, that is, applying the results to ranges beyond those of the test. While in part his deduction that the loss diminishes with increasing length of insulated electrode, agrees with the rigid analytical result, yet if he had continued his range of tests he would no doubt have found a turning point at which the loss again increases. He would also have found that under different conditions this turning point would be at an entirely different length of electrode, perhaps much shorter than his greatest length, or perhaps even still longer. Hence a general rule that electrodes should be long, is not at all correct.

His deduction that "It is apparent from the data given that the efficiency of a graphite electrode, regardless of its length, within reasonable limits, of course, increases rapidly with increasing current density" is another instance in which it is dangerous to exterpolate, for while this is true for that particular test, the writer could describe other and not at all abnormal conditions under which exactly the reverse would be true; hence it is not a general law. It may be safely stated that electrodes should not be proportioned according to current density; to do so may lead one away from rather than toward the desired end.

The statment in his last paragraph that for carbon the loss would probably increase instead of decreasing with the length, is also borne out only in part by the rigid analysis. The writer could state conditions under which the reverse would be true, and if so, it is not a general law. However, the latter case would probably be the exceptional one and the former the more usual.

Mr. Hansen seems to add the heat conduction loss to the C^2R loss to get the total. This is not correct; they do not add arithmetically in this way. The summation of these two losses is not such a simple relation.

There is a tendency among some people to discourage and even belittle what they call theoretical researches. If, however, a problem involves a large number of variables, as this one does, it is, in the writer's opinion, often far simpler, quicker, cheaper and more reliable to first work out the theoretical relations and then confirm them by experiment, than to make the experiments first and then deduce the laws from them. The number of experimental variations necessary to do the latter increases with enormous rapidity as the number of variables increases, and even then the inaccuracy of the constants and the measurements may lead one to a complicated relation when the real relation may be quite simple. Moreover in purely experimental researches the interpretation of the results and especially any exterpolation beyond the experimental range, may often lead one away from the right direction. From the results which the analytical investigation shows in this case, the writer feels sure that it would have taken very extended and expensive experimental researches to have determined the true laws of electrode losses which teach us what the best possible results are and how to design electrodes in order to approach them as closely as practicable; also to show us how each of the many variables will effect the result. In the present case these laws show not only how to design the electrodes and what limits it would be useless to try to exceed, but also how one may best select those of the original constants of the furnace itself which are open

to choice (like the relation between the volts and amperes for a given output in watts) in order to reduce the percentage which the loss in the electrodes bears to the whole, and hence increase the total efficiency of the furnace. It is possible now to calculate electrodes more accurately than the constants are known, or than it is possible to carry out the conditions in practice. This would evidently not have been the case had the laws been determined empirically.

Philadelphia, Pa.

Influence of Arsenic and of Tin Upon the Magnetic Properties of Iron.

By Charles F. Burgess and James Aston.

It is an interesting fact of both scientific and commercial importance that pure iron is not necessarily the best iron for use in electrical machinery or apparatus where it is desirable to keep down the magnetic losses. Indeed, the addition of certain elements to this iron may greatly improve the magnetic properties. The addition of silicon has so greatly improved the materials used in transformer construction as to have given rise to what may be termed a revolution in the transformer industry.

The success in the use of silicon calls attention to what may be accomplished by the use of certain other alloying elements, and the purpose of this paper is to point out the apparent influence of arsenic and of tin, elements which, in the experiments here recorded, show a material reduction in hysteresis losses and an increase in permeability as compared with an approximately pure iron taken as a standard.

The results here given are submitted with due appreciation of the fact that methods of making magnetic tests are not sufficiently accurate or standardized to make the measurements of different observers strictly comparable. Also, that the alloys produced and upon which measurements have been made are not sufficient in number to warrant the assumption that factors other than the alloying agent may not have some influence upon the results which have been obtained.

In a paper presented at the fifteenth meeting of the American Electrochemical Society in May, 1909, the writers gave the results of observations on alloys of electrolytic iron with

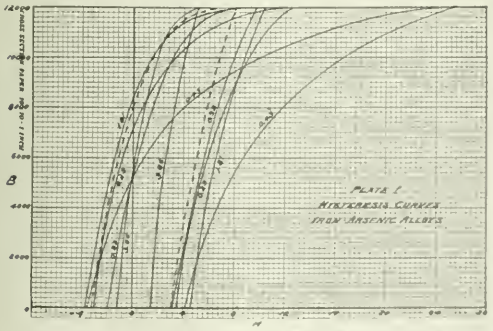


FIG. 1.—HYSTERESIS CURVES IRON-ARSENIC ALLOYS

arsenic and bismuth in which the analyses of the electrolytic iron in the various iron alloys used are given; also the methods of preparing the samples and of conducting the tests. The data here given are an extension of this work, the results of further measurements, and a description of alloys with tin, a metal which is shown to have much the same influence on iron as has arsenic.

The magnetic tests are made with an Esterline permeameter The alloys were prepared by melting electrolytically refined iron with different proportions of arsenic and of tin in magnesia crucibles placed inside of graphite containers and heated in an electrical resistor furnace The ingots weighing about one pound were subsequently forged into rods and machined into bars 1 cm in diameter. These bars were tested for their magnetic properties under various heat treatments.

Check analyses have been made to determine the actual content of tin and arsenic. In the case of the arsenic the analyses checked closely with the amounts added to the crucible up to about 4 per cent, while in the case of tin there were material discrepancies between the amount added and the amount found in the resultant ingot.

As noted in the above mentioned article, the magnetic tests

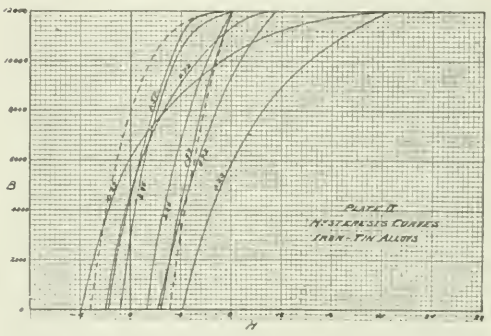


FIG. 2.—HYSTERESIS CURVES. IRON-TIN ALLOYS.

are all compared with a forged electrolytic iron sample, which is used as a standard. In the following table is given the analysis of this bar, together with the compositions of the original anode stock of Swedish iron and the resultant product after two electrolytic refinings:

Per Cent.	Anode.	Double Refined.	Electro-forged.
C	0.200	0.012	0.047
S	0.007	None	0.005
Si	0.109	0.013	0.002
P	0.007	0.004	0.016
Mn	0.021	None	None
Iron (difference)	99.971		

As will be seen from this table, the refined material has a purity of 99.97 iron and is representative of the material used in the preparation of the alloys.

The magnetic tests were made upon all samples under four different heat treatments—first, as forged; second, after heating to 675° C. and slowly cooling. third, after heating to 1000° C. and slowly cooling, fourth, after heating to 900° C. and quenching in water In our general series of tests the quality is indicated by a magnetization or B-H curve and by readings of the retentivity and coercive force In this paper, since alloys of arsenic and tin are of promise mainly for transformer working, where low hysteresis loss is the governing factor, these results have been determined for a fixed value of flux density (B = 12,000) and are here plotted.

In Table I the quality of the standard is given and can be compared with the Swedish anode material, which anode stock is of a quality comparable to ordinary high grades of wrought iron. The standard reference loop for electrolytic iron is indicated in the plates as a dotted curve. It is not the best pure iron sample which we have tested, but is satisfactory as a standard in showing that if the alloys equal this material they have exceptional magnetic qualities.

Arsenic.

Tests of the iron-arsenic alloys under the four different conditions previously mentioned have been made upon the following

Bar	Calculated per cent arsenic.	Actual per cent arsenic.	Carbon Per Cent.
121 I	0.25	0.292	....
121 II	0.50	0.430	....
113 A	1.0	0.915	....
113 B	2.0	1.810	0.042
113 D	4.0	3.862	....
113 F	6.0	4.141	
113 H	10.0	3.563	

TABLE I.—MAGNETIC TESTS DATA.

Bar.	Comp. Per Cent. Added.	Annealed 900° C.	I. Annealed 675° C.	Annealed 1000° C.	Quench 900° C.	II. Annealed 675° C.	Annealed 1000° C.	Quench 900° C.	II. Annealed 675° C.	Annealed 1000° C.	Quench 900° C.	II. Annealed 675° C.	Annealed 1000° C.	Quench 900° C.
Armco		9,500	10,000	13,200	8,400	14,200	13,900	12,050	16,500	15,700	15,850	15,550	Unannl'd	18,150
17 A		13,100	10,000	13,350	11,800	15,750	15,450	14,600	17,600	17,000	17,050	16,950	18,850	18,200
Vacuum														
121 I	0.29	10,500	13,200	10,800	11,400	14,750	15,550	14,750	17,450	16,900	16,500	16,700	18,350	17,850
121 H	0.43	7,000	7,800	10,400	8,100	13,600	14,000	13,750	16,300	16,600	15,950	16,250	17,800	17,550
113 A	0.92	6,200	6,250	11,950	12,600	13,200	14,050	14,750	15,300	16,450	17,000	16,050	17,950	18,250
113 B	1.81	8,400	11,800	12,600	10,300	13,950	15,750	15,150	13,800	16,700	17,450	16,850	18,150	18,250
113 D	3.86	12,400	14,200	12,300	13,450	15,000	16,100	14,600	15,450	16,700	17,550	16,850	17,950	18,000
113 H	4.85	11,500	15,000	13,850	13,600	15,350	16,300	15,750	15,450	16,450	17,550	16,850	18,050	17,350
113 F	4.14	13,300	14,200	14,650	...	15,500	15,900	15,700	...	17,000	17,050	...	18,200	18,100
Tin.														
111 B	0.29	2,150	8,650	9,400	9,000	9,300	13,600	13,150	13,000	16,350	16,650	16,150	16,250	18,250	17,000	17,900
103 C	0.34	3,900	6,400	9,400	11,000	10,550	13,200	13,300	14,150	16,450	16,700	16,250	18,600	18,350	17,900	17,900
103 D	0.69	5,800	7,600	11,300	13,750	12,450	13,750	14,800	15,750	16,300	16,950	16,000	18,100	18,650	18,200	18,400
111 &	0.72	8,400	11,700	11,300	14,150	13,050	15,600	15,200	16,300	17,500	17,900	17,350	19,250	19,200	18,500	18,700
111 A	1.57	8,700	12,000	13,300	14,350	13,300	15,200	15,750	15,550	16,300	17,100	17,150	18,600	18,400	18,300	17,600
121 J	2.06	12,900	12,400	13,850	13,550	14,750	15,200	15,000	15,350	16,200	16,750	16,450	17,250	17,950	17,400	17,500

In addition, later tests have been made upon bars of added arsenic content of 1, 3 and 5 per cent, but analyses have not been made to confirm these percentages. Although the arsenic was supposed to be present up to 10 per cent, analysis shows 4.141 per cent as the maximum, seemingly the saturation point under the conditions of our melt. Below this percentage the arsenic is taken up by the iron in about the added proportions.

The material formed sound ingots and forged easily throughout. The bars were readily machined, but were brittle for the higher arsenic content. The alliaceous odor was very evident upon the slightest heating, being very intense during forging and readily detected even upon slight heating, due to grinding. Data of the magnetic tests are given in Tables I and II and typical curves are plotted in Plate I. The higher densities are in general reached after the annealing at 675°, while the minimum hysteresis losses at low magnetizing forces are obtained by annealing at the higher temperature of 1000°.

The hysteresis curves, however, are plotted for a fixed maximum density of 12,000 lines per square centimeter, after the last heat treatment, the quenching at 900° C. This heat treatment in reality amounts to an additional annealing, since no hardening was observed, due no doubt to the absence of carbon in the alloy. This can be seen by inspection of Table II, where the coercive forces become successively lower, even after quenching.

Nothing of particular interest is brought out in the alloys of low arsenic content. Those with a very low percentage of arsenic lie close to the electrolytic standard; with additional arsenic there is a falling off in quality. The most interesting features are noted with the iron-arsenic content of 3.86 per cent, 4.14 per cent and 3.56 per cent. Very high flux densities are reached for small impressed fields, especially after annealing, where these arsenic alloys are equal to the electrolytic material for values of H above 50 and are considerably superior below, thus ranking with the best material for which records are available.

The value as magnetic material is more clearly brought out in the hysteresis loops plotted in Plate I and the data given in Table III. There is a marked decrease in the area of the loop (which is representative of the hysteresis loss per magnetic cycle for the bar) with a high arsenic percentage of 3.86. Relative areas compared with the electrolytic standard as unity are 1.08 and 1.26, for arsenic 0.29 per cent and 0.43, respectively; this area falling off to 0.56, with arsenic 3.56 per cent, and to 0.39 for the bar with 3.86 per cent arsenic.

In our previous paper we recorded also the effect of the addition of arsenic to ordinary iron. A good grade of transformer sheet steel was melted into ingots alone and with an addition of 5 per cent of arsenic, then forged and turned into test bars. The result was a marked improvement in the magnetic quality, due to the addition of the arsenic. The effect was particularly pronounced for the lower magnetizing forces.

Tin.

A number of alloys of iron and tin were tested, of which the following six were analyzed and form the basis of this discussion:

Bar.	Per Cent Tin. Added.	Analysis.	Per Cent Carbon.
111 B	0.2	0.288	.....
103 C	0.5	0.342	.....
103 D	1.0	0.968	0.095
111 &	2.0	0.717	.....
111 A	3.0	1.568	.....
121 J	4.0	2.059	.....

This series is somewhat analogous to the iron-arsenic series in that the volatilization point of the tin is reached before the fusing point of the iron. The analyses show that a considerable amount of the tin has been lost (about 50 per cent), but that there is still a large percentage remaining and that the bars have a resultant tin content varying in the order of the added amounts.

The data of the magnetic tests are given in Tables I and II, and representative results are plotted in Plate I. The hysteresis loops are again those obtained after quenching at 900° C.

As in the arsenic series, we note nothing of particular interest in the alloys with lower percentages of tin. They are comparable to the electrolytic standard. The real value is indicated in the hysteresis data where there is to be noted a perceptible falling off in the loss with the increase of tin. This loss is especially low in the alloys of highest tin content of 1.57 per cent and 2.06 per cent, where the relative areas are 0.67 and 0.40, respectively, compared with the standard as unity.

Comparisons.

Magnetic testing is not on such a basis that data from various sources can be taken as absolute, and on this account comparisons are apt to be misleading. Recognizing this fact, we have endeavored to make our comparisons more exact by collecting samples of commercial material and testing this upon our own apparatus. In Plate III and Table III are given the results of tests upon representative samples of high-grade materials, including silicon steels from several manufacturers and users. AM is a very pure commercial iron (99.88-Fe). AP and M are silicon sheet steels for transformer service. F is an electrical sheet steel, composition unknown.

At this place it may be well to mention that we have also made alloys of iron and silicon and our results are analogous to those of commercial silicon sheets. Our material, of course, differs essentially in being a binary alloy, practically free from the other elements usually met in practice.

In addition to the column in Table III showing the relative hysteresis losses by means

TABLE II—COERCIVE FORCE AND RETENTIVITY.

Bar Iron	Comp. Per Cent.	Unann'd	H (Max) = 200 Coercive Force Ann'd 675	Ann'd 1000	Quench 900	Unann'd	H (Max) = 200 Retentivity Ann'd 675	Ann'd 1000	Quench 900
N S W	Anodi.	5.5	4.8	3.9	5.0	11,400	12,700	9,000	8,500
117 A	Elec forged	5.5	6.2	5.1	2.5	12,300	13,800	10,000	8,000
ARSENIC.									
121 I	0.29	6.5	5.5	4.5	4.0	12,400	14,000	9,900	10,800
121 H	0.43	8.2	8.0	5.5	4.3	12,700	14,700	9,400	8,600
113 A	0.92	9.5	9.1	5.3	3.0	12,700	14,700	12,300	9,500
113 B	1.81	5.9	5.0	3.7	3.0	10,300	12,200	8,900	8,600
113 H	3.56	4.5	4.0	2.7	2.7	11,000	13,400	8,600	8,900
113 D	3.86	4.0	3.5	2.0	2.1	12,100	13,000	6,500	8,600
113 F	4.14	5.0	3.3	2.3	...	10,800	12,300	8,900	....
TIN.									
111 B	0.20	23.5	7.5	5.3	5.0	12,100	11,700	9,100	8,700
103 C	0.34	12.3	8.9	5.5	3.6	12,300	12,700	9,400	8,600
103 D	0.69	7.5	7.7	4.3	3.7	8,000	12,300	10,400	12,100
111 K	1.72	7.0	5.7	3.9	2.9	11,000	13,200	8,700	8,900
111 A	1.57	6.0	4.0	4.0	3.3	10,000	13,100	11,900	10,800
121 J	2.06	3.0	4.3	3.5	2.5	8,100	11,300	9,300	8,600

of the integrated areas of the loops, we have added a column designed "relative value," and in which we have endeavored to represent the values of the materials for transformer working more consistently than is done by taking into account the hysteresis losses alone. For example, in Table III, in integration of the loops for electrolytic and Swedish iron at the same working density of B = 12,000, the hysteresis loss for the latter is 0.94, compared to electrolytic material as unity. But to reach this density the Swedish iron requires a magnetizing

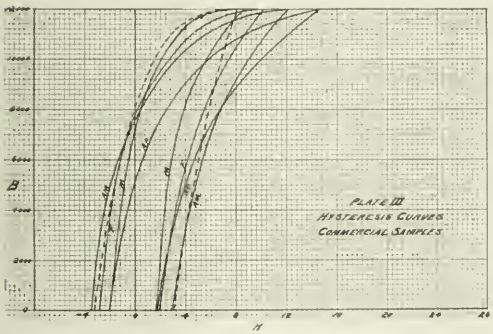


FIG. 3.—HYSTERESIS CURVES. COMMERCIAL SAMPLES

force of 13 and electrolytic iron but 8. Evidently, therefore, the greater number of turns necessary, together with the increased length of magnetic circuit required to give space for this extra winding, makes Swedish material of lower grade

To take into account these various factors we find that a

TABLE III. RELATIVE HYSTERESIS LOSSES.

Bar.	Comp. %	Loop Area in².	Relative Area.	B(Max) = 12000 H(Max)	Relative Value
IRON					
N S W	Anode	8.14	0.94	3.9	1.49
117 A	Elec forged	8.65	1.0	8.0	1.0
ARSENIC.					
121 I	0.29	9.36	1.08	12.7	1.67
121 H	0.43	10.00	1.26	25.4	3.90
113 A	0.92	7.41	0.86	9.8	1.01
113 B	1.81	11.01	1.34	10.5	1.72
113 H	3.56	4.88	0.56	6.2	1.43
113 D	3.86	3.37	0.39	5.1	0.24
TIN.					
111 B	0.20	11.42	1.32	26.2	3.26
103 C	0.35	9.59	1.11	20.5	2.77
103 D	0.66	8.01	0.93	11.1	1.19
111 K	0.72	6.09	0.70	7.5	0.99
111 A	1.57	5.86	0.67	8.0	0.97
121 J	2.09	3.46	0.40	8.1	0.10
COMMERCIAL.					
F	Sheet steel	7.25	0.84	9.0	1.22
VP	Silicon sheet	5.77	0.67	14.7	1.20
M	Silicon sheet High purity iron	5.70	0.66	8.7	0.64
VM		9.18	1.06	12.1	1.73

very fair approximation of the value is obtained by making the comparison on the basis of the relative products of the loop area, times the magnetizing force required to reach the fixed density of B = 12,000 per sq. cm. These figures, compared to the standard electrolytic bar as unity, are plotted in the column "relative value."

Examination of the above table shows several materials with lower hysteresis losses than the electrolytic standard. Among these are a number of commercial samples; and of the alloys we note those of high arsenic and high tin content. The materials having the very lowest losses are the two bars of highest percentages of arsenic and tin. These comparative figures are better shown in the column of relative values, where, as discussed above, there is taken into account also the magnetizing force required to reach the maximum density of 12,000 lines per sq. cm.

The addition to iron of arsenic and tin has the desirable effect noted with silicon, viz., an increase of the electrical resistance with a consequent reduction of eddy current losses. Should further investigation show ageing qualities comparable to those of the silicon alloys, these iron-arsenic and iron-tin alloys are worthy of attention for transformer working in view of the evident low hysteresis and high permeability.

The above results were obtained as a part of a more extended investigation carried on under a grant of the Carnegie Institution, of Washington.

Chemical Engineering Laboratories,
University of Wisconsin.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our London Correspondent.)

Iron and Steel Institute.

Continuing the discussion on Mr. Rodenhauser's paper on **electric steel furnaces**, the first part of which was recorded in our last issue, Prof. Turner said that with direct current electrolytic action might decompose phosphide and sulphide. He considered that induction furnaces were not suitable because they did not attain a sufficiently high temperature.

Mr. F. Moorwood thought the induction furnace did not lend itself to handiwork, and that the resistance furnace was better adapted to the existing steel-works plant and to more ready handling by the workmen. The electric furnace should now pass out of the hands of the electrician into those of the steel maker

Mr E Adamson said the author seemed to suggest that the steel made in the Héroult furnace was not so homogeneous as that produced by the Roechling-Rodenhauser plant. Speaking from his practical experience he could say that steel made in a Héroult furnace was quite homogeneous, and he quoted analytical results in support

Mr V. Cooper said he had seen the furnaces at work and brought away samples of the steel, which gave results corroborating the analyses given by the author, but the metal being used was not from a Bessemer converter, but from a basic Bessemer converter Consequently, there were two distinct processes of manufacture He thought that, for rail steel, until metal was taken from the blast furnace or from the mixer, the electric furnace could not become a serious competitor with the open-hearth process. In Middlesborough it was easy to make steel of the same composition as that given by the author with 0.004 per cent of sulphur and 0.023 per cent of phosphorus by

the basic open-hearth process. He was associated with a works at which 30,000 tons of rails had been made which were capable of withstanding the test stated by the author.

Mr T. Rowlands gave details of an induction furnace demonstration plant at Niagara. Steel containing 1.2 per cent of carbon had been melted with a consumption of 440 kw-hours per ton. In another instance ferro-manganese was melted with 520 kw-hours per ton, and the figure for manganese steel was 600 kw-hours per ton. Pure iron had also been melted, with addition of silicon in the ladle, for making selected steel.

Mr. Frick, with reference to the temperature question, said they had attained from 1650 deg. C. to 1700 deg. C. His remarks on the removal of slag had reference to his own type of furnace only.

Mr. Rodenhauser, in reply, said he had not been able to follow all the questions in the discussion, and would make a deferred written communication. Steel rails of higher resistance were made in the electric furnace with an expenditure of about 100 kw-hours per ton, but at this low figure it was not possible to make steel of a high degree of purity. There was no difficulty in attaining any required temperature in the induction furnace, and they were now working a three-phase furnace in which any requisite temperature was obtained.

* * *

Dr. M. Ekenberg's paper on **"fuel from peat"** followed.

Mr J. E. Stead said he could vouch for the accuracy of the author's statements bearing on the chemistry of the process. More than 20 years ago he had investigated a scheme for smelting iron with peat, and found that the heat evolved was only sufficient to vaporize the associated water; and, therefore, if peat were to be produced in a dry state it must be air and sun dried. Dr. Ekenberg's discovery had made the recovery of peat fuel possible. Pressure alone did not squeeze out the water, but by the simple process of heating under pressure to 200 deg. C. the hydrocellulose was altered in character and could be separated from the water by filtration. He believed that this process would render available as a source of power the vast mass of fuel in the peat bogs.

Mr Andrew Lamberton said the paper had reference to the steps designed to avert waste of material, and if the author's process effected what was claimed for it, then the matter was of the greatest importance to the institute.

Dr Ekenberg replied. Some acid was formed in the process of heating, but the iron tubes did not corrode to a greater extent than would be represented by a depreciation of 10 per cent.

The discussion on **"A heat-treatment study of Bessemer steels,"** by Professor McWilliam and Ernest J. Barnes, was opened by Mr. W. Beardshaw, who remarked that when he became president of the Sheffield Society of Engineers and Metallurgists they presented a Brayshaw furnace to the university, and that paper was the first outcome of that presentation. It was desirable that experiments should be made on a larger scale. He had made many tests on samples up to 6 in. in diameter. In a bar of large diameter he found that the core and the exterior gave different results: on the outside the ultimate stress was 48 tons, the yield point was 32 tons, and the extension in 2 in. was 23 per cent. In the core the ultimate stress was 44 tons, the yield point 27½ tons, and extension identical. On a 1½ in. square bar the ultimate stress was 49 tons, the yield point 38 tons, and extension 33 per cent.

Mr. J. Gledhill agreed that experiments on larger pieces would be useful. Professor McWilliam's experiments were academical, and we wanted to know more about heat treatment of masses. Over-annealing lowered the tensile strength, but increased the resistance to shock. Material of a durable nature with increased elastic limits was a desideratum.

Mr. Stead asked whether alternating tests had been applied at Sheffield on cross-sections of plates and bars. He found that in alternating bend tests stresses in one direction are double those taken in another (longitudinal and cross). The alternating bend test indicated the direction of the rolling. He would like to see microphotographs. Striation occurred in every steel containing less than 0.04 per cent of carbon. Such steels might be condemned, but were perfectly good. Manganese sulphide was associated with high phosphorus.

Professor McWilliam, in his brief reply, pointed out that his experiments on 1-in. bars were not entirely academical. Much practical work was done with bars of these dimensions.

A New Calorimeter.

At a recent meeting of the Physical Society Dr. C. V. Drysdale exhibited the new thermo-electric calorimeter of Féry, which can be used without intermission and gives the heat-producing value of gas at any required instant. The gas to be tested is burned under constant pressure in a special burner at rates varying from 5 liters to 10 liters per hour. The incandescent gas heats the hot junction of a thermopile, while the air supply traverses the cold junction. The thermopile has 15 pairs, and can give an e.m.f. of 0.2 volt, which is sufficient to work a recorder, as in the case of the Richard thermograph and barograph.

Market Prices, July 30th.

Tin.—Starting at £131 10 0 fluctuated between this price and £129 18 0 twice during the first fortnight, becoming steadier on the 14th and finally rising to £132 15 0.

Copper.—Has kept fairly steady for this metal between £58 and £59, becoming harder in the middle of the month, but finally falling to £58 12 6 (July 29).

English Lead.—Dropped slightly on the 7th; since steady at £12 or a little over, rising to £13 on the 21st; final price (29th) £12 18 9.

Iron Cleveland Warrants.—Commenced at 47/-, rose to 48/- on the 18th and finished at 48/9½.

Scotch Pig.—Was steady at 53/- till the 20th, when rose, finishing at 54/10½.

Hematite.—Dropped badly from 56/- to 52/10 on the 13th., recovered sharply and remains at 56/6.

Antimony, black sulphide powder, per ton	£25	0	0
Sulphate of ammonia, f.o.b. Liverpool	11	2	6
Copper sulphate	18	17	6
Caustic soda, white, 77 per cent	11	2	6
Bleaching powder, 35 per cent	4	5	0
Shellac, standard T. N., orange spots, cwt.	3	10	0
Carbolic acid, liquid, 97 to 99 per cent, gallon			10½
Creosote, ordinary good liquid, gallon			2½
Naphtha solvent, 90 per cent at 160 deg. C., gallon			8
Rubber, Para, fine, pound		8	3
Platinum, per ounce	4	11	6

RECENT METALLURGICAL AND ELECTROCHEMICAL PATENTS

Smelting of Titaniferous Iron Ores.—The object of a new process of Prof. W. Borchers is the treatment of a titaniferous iron ore for the production of pig iron containing the silicon but not titanium. The titanium passes into the slag and this slag is directly used as the reducing agent for fresh quantities of ore. Limestone or any other fluxes forming fluxes are rendered superfluous. The inventor proceeds as follows: On putting the plant for the first time into operation, titaniferous iron ore or titaniferous iron sand is put into a suitable electric furnace and carbon is added, whereupon the contents of the furnace are smelted. Later on, when the plant is in its regular working condition, a deoxidizing agent, more fully to be described below, is added at a temperature lying near but not much above 2000 deg. C., in quantities sufficient to extract the main bulk of the iron and all of the silicon present. The resulting smelting products are a crude iron which contains practically the whole amount of the silicon of the ores, and a slag which contains a small part of iron, but very much titanic acid. For

the success of this operation, it is necessary, however, that the quantity of silica (SiO_2) of the ore is not as large as in the poorer kinds of titaniferous iron sands, of which it sometimes forms 20 per cent and more. In such cases a magnetic dressing of the ore would easily produce concentrates with but very few per cents (1.5 to 3 per cent) of silica, which can be easily reduced according to the present process. For complete separation of the titanic acid by means of this smelting operation the quantity of the deoxidizing agent must be so chosen that with every 10 to 15 parts by weight of the titanium present one part by weight of iron will go into the slag. Lime or other fluxes are not used in this process.

After a sufficient quantity of slag has collected—eventually after repeated tapping of the crude iron which contains the reduced silicon, so that the necessary steps can be taken to put the slag to its proper use—the slag will be electrically heated either in the same furnace after the crude iron has been drawn off, or in another furnace to a higher temperature, estimated to exceed 2500 deg. C. Then carbon in the shape of coke, charcoal and the like is added in a heated condition and the slag is now reduced to a product which principally consists of iron, titanium, and carbon, which product must be considered as a mixture of carbides, titanides, and variable amounts of free titanium. This mixture forms an energetic reducing agent, which is employed as such for reducing the titaniferous ore, in the place of coal or coke hitherto used for this purpose.

The characteristics of the present invention therefore reside in the following facts: 1. Reducing iron ores rich in titanium to crude iron which contains silicon and is free from titanium, and a slag poor in silicon and rich in titanium. 2. Transforming this slag without a previous cooling off through a comparatively little increase in temperature by means of carbon into a highly reactive reducing agent. 3. Utilization of the reducing agent obtained according to point 2 for the purpose of reducing the ore according to point 1 as much as this process demands, and utilization of an eventual over-production of such reducing agent for other metallurgical operations. (930,344, Aug. 10 1909.)

Precipitation of Copper from Solutions.—To precipitate metallic copper from a copper sulphate solution, L. Jumau, subjects it to a high temperature under pressure in the presence of sulphurous acid, produced in the previous roasting process. The copper is precipitated from the solution in the form of pure metallic copper, and the sulphurous acid is oxidized to sulphuric acid, according to the equation

$$CuSO_4 + SO_2 + 2H_2O = Cu + 2H_2SO_4$$

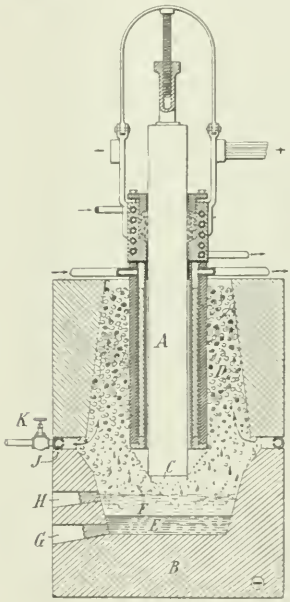
The percentage of copper precipitated increases as the temperature is raised.

Temperatures	Copper Precipitated
140°C	47 per cent
155°C	62 per cent
167°C	65 per cent
190°C	70 per cent

To avoid an excessive pressure due to the high temperature necessary, the inventor employs only that quantity of sulphurous acid which is theoretically required without attaining saturation and then heats the whole gradually. Or, he first heats the solution without sulphurous acid, and then introduces the latter as gas under pressure, adding gradually only the theoretical quantity. (930,967, Aug. 10, 1909.)

In a modification of this method, also due to L. Jumau, the solution is subjected to a high temperature in the presence of wood in any form, such as saw-dust, shavings, waste wood and the like. This process is particularly advantageous when the ores do not contain sulphur, as no sulphurous acid is then furnished by a previous roasting process. The solution thus treated yields metallic copper, and, as product of decomposition of the wood, organic acids and carbon dioxide that can be absorbed by putting the apparatus in which the solution is heated under pressure, into communication with a space filled with some absorbent of carbon dioxide, such as lime; however, the carbon dioxide may escape freely through the valve of the digester. (930,968, Aug. 10, 1909.)

Electric Smelting Furnace for Copper Ores.—In the usual process of treating copper ores, the ore is smelted to obtain a matte of copper sulphide and iron sulphide, while the silicates and other impurities which constitute the gangue are eliminated. The percentage of copper in the matte may vary from 30 to 60. The matte is then subjected to a converter process by which the iron and most of the sulphur is burned out, leaving black copper approximately 90 per cent pure. Dr. P. L. T. Heroult proposes an electric-furnace process which permits perfect regulation of the heat on one hand and regulation of the consumption of iron and sulphur on the other hand, so that a black copper or a rich matte may be obtained without special difficulty, and directly from ores of widely varying compositions. The process consists in feeding the ore into an electric furnace and fusing it by electric heat, and simultaneously injecting oxygen into the ore for the oxidation of the iron and sulphur. The advantage of this process is the separation of the step of oxidizing the iron and sulphur from the step of fusing. The fusing, on the other hand, is affected without oxidation. Therefore a wide range of operations may be effected with perfect accuracy, ranging from mere fusion without any oxidation of impurities on one hand to complete oxidation of the iron and sulphur on the other hand. In above figure current enters through the electrode *A* and passes out through the body *B* of the furnace. The arc is indicated by *C* and the zone of fusion by the drops of molten material. The ore *D* is introduced at the top of the furnace and is gradually fed down through the zone of fusion, the resulting product forming to a pool *E* at the bottom of the furnace, with a layer of slag *F* floating thereon. The desired product *E* and the slag *F* are drawn off at desired intervals through tap holes *G* and *H*. The air is introduced through an annular pipe *J* above the zone of fusion and mingles thoroughly with the ore, rising through the same and effecting the reduction described. A valve indicated typically at *K* determines the pressure or quantity of air injected. (930,666, Aug. 10, 1909.)



COPPER SMELTING FURNACE.

Treatment of Slimes in Electrolytic Lead Refineries.—Hitherto slime produced in electrolytic lead refineries, working on the Betts process, has always been collected with considerable trouble, and washed to recover the lead depositing electrolyte contained in it before being submitted to chemical or metallurgical treatment, and even then there is a loss of lead-depositing electrolyte. A simpler and more rational treatment of the slimes has now been worked out by Mr. Anson G. Betts. He has found that he can dissolve both the antimony and lead in the slime, as well as copper, silver and arsenic, if desired, by the use of a solution containing an acid making a soluble lead salt,

e.g. fluosilicic acid and also hydrofluoric acid in moderate quantity. A solution of lead fluosilicate and fluosilicic acid containing 5 to 6 per cent lead and 15 per cent SiF_6 ion permits the addition to it of as much as 5 per cent, anhydrous HF at a moderate temperature, and considerably more at an elevated temperature. Such a solution containing 5 per cent HF is capable of dissolving 10 per cent antimony as trifluoride, and a solution of antimony trifluoride even in large proportions will not precipitate lead fluoride from a lead solution, as the addition of most fluorides—for example, sodium fluoride—will do. Betts prefers to use, then, to take the metals of the slime into solution, a liquid containing considerable fluosilicic acid, and a moderate quantity of hydrofluoric acid. Lead peroxide used in connection with fluosilicic, or other equivalent acid, will not cause metallic lead, copper, etc., to go into solution as fluosilicates, etc., but will also cause antimony to go into solution as fluoride, if hydrofluoric acid is present in a moderate proportion.

As the solution becomes more neutral, the precipitating power for lead of the hydrofluoric acid becomes greater, from the increasing proportion of lead to be precipitated, and the decreasing proportion of fluosilicic acid remaining to tend to dissolve any lead fluoride formed. However, the proportion of hydrofluoric acid becomes less as antimony trifluoride is being forced, so no lead fluoride is precipitated. Similar changes take place in a reverse direction in the preferred method of electrolyzing the solution described below. Lead peroxide is a powerful oxidizing agent sufficiently so to cause the formation of silver salts from metallic silver, so it is possible to dissolve practically all of such metals of the slime as copper, lead, antimony, tin, silver and certain amounts of bismuth. To quicken the reaction, Betts grinds the lead peroxide finely.

In the practical execution of his process, Betts proceeds as follows: The lead anodes are suspended in a tank in the usual way with the usual cathodes, and the whole electrolyzed until the anodes are pretty well dissolved. By suitable means, below or after siphoning the clear solution out of the tank, the slime is caused to drop from the anodes to the bottom of the tank. After removing the scrap he then adds about the theoretical amount of peroxide necessary to carry out the following reactions:

$$Pb + PbO_2 + 2H_2SiF_6 = 2PbSiF_6 + 2H_2O$$
$$Cu + PbO_2 + 2H_2SiF_6 = PbSiF_6 + CuSiF_6$$
$$2Ag + PbO_2 + 2H_2SiF_6 = Ag_2SiF_6 + PbSiF_6 + 2H_2O$$
$$2Bi + 3PbO_2 + 6HF + 3H_2SiF_6 = 2BiF_3 + 3PbSiF_6 + 6H_2O$$
$$2As + 3PbO_2 + 3H_2SiF_6 = As_2O_3 + 3PbSiF_6 + 3H_2O$$
$$2Sb + 3PbO_2 + 6HF + 3H_2SiF_6 = 2SbF_3 + 3PbSiF_6 + 6H_2O$$
$$Sn + 2PbO_2 + 4HF + 2H_2SiF_6 = SnF_4 + 2H_2SiF_6 + 4H_2O$$

The reactions with bismuth and tin are of minor importance, as these elements are usually absent or occur in relatively small quantities. The tank is nearly filled with strong H_2SiF_6 solution containing some lead which may have the composition SiF_6 ion 20 per cent, lead ¾ per cent, HF 1 to 2 per cent, and stirred preferably until solution is practically complete, or until the slime gets so thin from the solution of its antimony that it can readily be drawn off, which it is difficult to do with most raw slimes, on account of their heavy nature. The tank is finally cleaned out and used to refine more lead. After action is practically complete, the solution, which may contain about 2 per cent antimony, 0.6 per cent arsenic, 1 per cent silver, 1 per cent copper, 18 per cent lead, and perhaps 0.1 per cent bismuth, the figures, of course subject to great variation, is filtered from gold, and undissolved silver, and lead peroxide.

The solution containing the various metals of the slime is led through the tanks in which are suspended copper plates, to precipitate out metallic silver. It then passes through a series of electrolytic tanks provided with carbon anodes and suitable cathodes, copper being good for some or all and lead for others, in which a current density is used varying from 5 to 10 or more amperes per square foot with an electromotive force of from 2.2 to 2.5 volts per cell. Electrolytic copper is deposited on the first cathodes, and continues to deposit until copper is reduced to, say, 0.1 to 0.2 per cent, when a solid alloy of copper and antimony deposits further on in the series of cells, and then impure lead and then fairly pure lead. Lead peroxide is deposited on the anodes throughout, so that only one anode product is obtained, which is ground and returned to be used in slime treatment.

The cathode deposits are better than expected and are quite satisfactory mechanically. The impure cathodes are worked up by using them as anodes in a refinery cell, in a series of tanks through which the solution from the slime treatment passes. For example, the copper-antimony cathodes are used as anode, and refined by the solution as it comes from the silver precipitation, copper and antimony going into solution together while pure copper deposits. In this way a certain amount of these cathodes are always on hand, but do not accumulate faster than they are worked up. The lead peroxide precipitates as a very hard, smooth conducting coating which warps slightly and drops off the anodes occasionally, or can be easily split off. More solution is obtained than was started with, as slime contained some to start with. Part of the solution should be partially neutralized by treatment with lead peroxide and lead, according to the reaction

$$Pb + PbO_2 + 2H_2SiF_6 = 2PbSiF_6,$$

and, after being passed through a special electrolytic lead refining cell with lead anodes and cathodes for the sake of removing any traces of impurities, passed back to the lead depositing plant. (918,647, April 20, 1909.)

SYNOPSIS OF PERIODICAL LITERATURE.

Thermo-Electric Pyrometer.—In *La Lumière Electrique*, July 31, 11. Pecheux describes the calibration of a copper-nickel thermoelement with the aid of a platinum, platinum-iridium couple. He finds that the copper-nickel couple may be usefully employed in the temperature range from 0 deg. C. to 920 deg. C. Within this range the c.m.f. increases in three different ways, namely, first, from 0 deg. to 235 deg., with an increasing temperature coefficient of the c.m.f., from 235 deg. to 390 deg. with a decreasing temperature coefficient, while from 390 deg. to 290 deg. the temperature coefficient again increases. For the couple calibrated by the author the law of the change of c.m.f. E with temperature t in degrees Centigrade is given by the following three equations:

(0 deg. to 235 deg.) $E = 24.38\,t + 0.0078\,t^2$
(235 deg. to 390 deg.) $E = 2124 + 43.50\,t - 0.035\,t^2$
(390 deg. to 920 deg.) $E = 7033 - 2.10\,t + 0.023\,t^2$

Boiling Points of Metals.—An approximate determination of the boiling points of metals, carried out at the University of Manchester, is described by H. C. Greenwood in a paper read before the Royal Society on May 27. The author employed a vertical carbon-tube resistance furnace, in which was suspended a long graphite crucible which contained the metal under investigation. Temperature readings of the outer walls of the crucible were taken by means of the Wanner optical pyrometer. The measurements of the boiling points were carried out by slowly raising the temperature of the crucible and observing the surface of the metal from above through an absorbing glass. At first the surface of the molten metal remains perfectly still, but as the boiling point is approached, a slight agitation of the surface is observed, which soon becomes vigorous. In the case of most of the metals studied the difference between the temperature, indicated when a gentle agitation is first apparent and that at which the ebullition has become so violent that globules of metal are being ejected from the crucible, does not exceed 100 deg. C. By taking the boiling point as that temperature at which ebullition becomes decided, quite concordant results were obtained in different experiments. Very great difficulties were encountered in boiling-point determinations of metals which

readily carburize. The remedy was to "brasque" carbon crucibles with highly shrunk pure magnesia. The following are the approximate boiling points found by the author:

	Deg.		Deg.
Aluminium	1800	Lead	1525
Antimony	1440	Magnesium	1120
Bismuth	1420	Manganese	1900
Chromium	2200	Silver	1955
Copper	2310	Tin	2270
Iron	2450		

Zinc Box White Precipitates.—In the August issue of the *Western Chemist and Metallurgist* Roy F. Coolidge gives an investigation of zinc box white precipitates. After a review of the subject he describes the analysis and treatment of white precipitates from Kendall, Mont. Zinc is the principal element and is present as hydroxide. "This is formed by the action of decomposed water on the zinc. The water is decomposed by the electromotive force developed by the zinc gold couple." $Zn + 2H_2O = Zn(OH)_2 + 2H$. Calcium, iron, aluminium, and magnesium are found in small quantities in the white precipitates. The gold present is mechanically mixed with the precipitates. The objections to the white precipitates are many and in one year's time they add greatly to the cost of operation. The white precipitate is quite soluble in KCN solution, and since increasing the mill solution to 3 lb. KCN per ton of solution with 1 lb. protective alkalinity, the Kendall mill is now troubled very little with white precipitate.

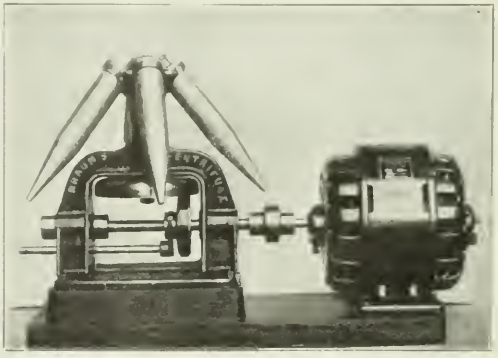
Electrochemical Industries.—The August issue of *La Houille Blanche* contains a paper by Octave Dony-Henault and C. Gall on the present status of electrochemistry and its applications. They first discuss the production of oxygen and hydrogen by electrolysis of water and note other methods for producing hydrogen (hydrolithe or calcium hydrate; decomposition of water by aluminium) and oxygen (oxylithe or compressed sodium peroxide; oxone or fused sodium peroxide; oxygenite or a mixture of infusorial earth and potassium perchlorate, with a small amount of charcoal). The authors then deal briefly with ozone, chlorine, bromine, sulphur, selenium, and tellurium, and then discuss at greater length the fixation of atmospheric nitrogen. After some remarks on the preparation of ammonia and electrolytic transformations of nitrogen compounds, they deal with the production of nitrogen oxide by electric discharges through air. They point out the reversibility of the reaction of $N + O = NO$, and the necessity of cooling quickly a gas mixture containing NO, in order to prevent its decomposition. The authors then deal more briefly with the production of phosphorus in the electric furnace, and arsenic, antimony, and tin, some remarks being made on detinning tin scrap. They then take up coron, silicon, calcium carbide and cyanamide. The article is to be continued.

Centrifuge.

Mixtures of liquids of different specific gravities or liquids containing sediments may be separated in the course of time by the simple process of settling under the force of gravity. But if the liquid be viscous the separation must be carried out quickly in order to make an analysis without delay; some greater force than gravity must be called into play. This is most conveniently supplied by rapidly rotating the materials at a high speed, setting up tremendous centrifugal forces.

In the Braun motor-driven "centrifuge," which, as shown in the accompanying illustration, consists of pivoted receptacles mounted to rotate about a vertical axis, the speed reaches more than 1500 revolutions per minute. Under these conditions the pound mass of the centrifuge tube exerts a centrifugal pull of about 320 lb., so that a sort of artificial gravity is produced 320 times as strong as the force of gravity. Since when in use the containers swing out horizontally the centrifugal force on the material in their extreme tips is about twice that at the center of gravity of the containers. Accordingly separations can be made with this apparatus in a very short time, while the adjustable speed friction drive enables the tubes to be started gradually and brought up to any desired speed.

The little motor shown, a ¼-hp Type A Westinghouse, is direct-connected to the friction-wheel shaft, which communicates its motion to the face wheel, giving a range of 1000 to 2000 revolutions per minute. The glass container tubes are surrounded by water and enclosed in an aluminium case, furnishing a cushioning surface which prevents breakage. The tubes contain 100 cu. cm. and are calibrated to tenths of a cubic centimeter, so that the results are easily and quickly read off. The motor-driven centrifuge is of recurring use in the laboratory and is almost an absolute necessity in the separation of heavy, thick, viscous liquids, such as crude oils, etc. The Braun centrifuge is manufactured by F. W. Braun, Los Angeles, Cal.



MOTOR-DRIVEN CENTRIFUGE.

Waste-Heat Air Heater.

Many operations in chemical and metallurgical engineering involve the transfer of heat between metal surfaces and fluids. Such transfer is involved in the operation of steam boilers, closed feed-water heaters, heating coils and radiators, economizers, condensers, evaporators, cooking kettles, etc. The rate of heat transference attainable obviously influences the design of these several apparatuses to a marked degree.

This rate may be expressed commercially as the number of British thermal units transferred per square foot of heating surface per hour per degree of difference of temperature and is usually designated by U. The magnitude of U is obviously affected by the following factors: first, the temperature, nature and condition of motion of the medium from which the heat is being transmitted; second, the thickness, material and condition of the intervening plate or tube surface; and, third, the temperature, nature and condition of motion of the fluid which is being heated. How great the influence of these several factors is upon the activity of the heat-transmitting surface will be apparent from an approximate statement of the values obtained in several different kinds of apparatus.

For boilers and economizers the value of U appears to vary between 2 and 3½ heat units per square foot per hour per degree difference of temperature. In heat exchangers, that is, appliances in which heat is transferred from one liquid to another through a metal surface, values of 50 to 60 are given for U. In closed feed-water heaters it is usually between 200 and 300, while in certain modern types of surface condensers values approaching 1000 are being obtained. Such a wide range of values cannot but cause the engineer to ask whether or not the performance of any one particular type of apparatus is at

the maximum possible or can be improved by changes in design or in methods of operation. In this article we shall describe some experiments made with this point in view upon the Green waste-heat air heater, a device for heating air directly from gases of combustion and similar in its general arangement to the Green fuel economizer.

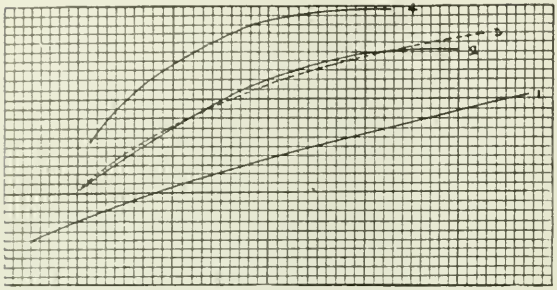


FIG. 1.—RELATION BETWEEN CUBIC FEET OF AIR PER PIPE PER MINUTE (ABSCISSAS) AND HEAT TRANSMITTED (ORDINATES).

It should be noted that whether air be heated in this device or by the ordinary means of steam coils, the source of the heat and its final destination are the same in each case. Where steam is used the heat is first transmitted from hot gases of combustion to the metal of the boiler, thence to the water and steam in the boiler, and again from the water or steam to the metal of the heating coil or radiator and, finally, to the air. In the present device the heat is transmitted from hot gases to the walls of the metal pipes and from these immediately to the air. With the same difference in temperature between the hot gases of combustion and the air, the capacity of the waste-heat air heater would undoubtedly be greater than the capacity of twice the amount of combined boiler surface and radiator surface, other conditions being equal. However, the heater is more usually employed for recovering heat from gases of combustion after the latter have already done service in a steam boiler or other apparatus. That is, the heater is usually employed as a means of fuel economy, saving the waste heat that would otherwise escape through the chimney to atmosphere and applying it to purposes for which steam would otherwise be required, or using it to preheat the air supplied to the furnace, thus increasing the temperature and efficiency of the latter.

In consequence of receiving gases at a lower temperature, the total amount of heat transmitted per square foot of surface is usually not as great as in a boiler, although the activity of the surface as measured by the number of heat units transferred per square foot per hour per degree difference of temperature is greater, particularly when the apparatus is operated with the special appliances herein described. As compared with a steam heater coil or radiator, the activity of the waste-heat air heater is comparatively high, due to the greater range of temperature, for, while an exhaust steam-heated radiator will rarely have a temperature much higher than 212 deg. Fahr. to 220 deg. Fahr., or a live steam heated radiator higher than 400 deg. Fahr., the waste-heat air heater may be receiving gases of a temperature of 1000 deg. Fahr., or higher, as for instance, the stack valve gases of water-gas generators or the waste gases from metal furnaces. When the apparatus is installed to receive the chimney flue gases from a steam boiler, the temperature will, as a rule, be between 500 deg. Fahr. and 650 deg. Fahr. The final temperature of the air heated by the apparatus will be determined by the use that is to be made of it. For heating and ventilating rooms in buildings this will be quite moderate, while for drying work it will be limited, as a rule, by the nature of the material being dried, although temperatures above 500 deg. Fahr. or 600 deg. Fahr. are sometimes employed.

The apparatus can be so connected up that the air will be passed through all the pipes in parallel or through groups placed in series. In the latter case it is customary to have the air enter the apparatus at the cold end—that is, the end from which the gases of combustion are leaving, and to leave the apparatus from the hot end, that is, the end with which the gases of combustion first come in contact, as by this means the greatest average difference in temperature is maintained throughout the apparatus. A perfect apparatus arranged in this way would be able to transfer all the heat of the hot gases to the cold gases. In making arrangements of this kind it was discovered that if the same number of cubic feet of air were put through the heater with one-half of the pipes arranged in series with the other half, the amount of heat transmitted per square foot of surface per hour per degree difference of temperature was increased 50 per cent to 75 per cent. This confirms results obtained by the engineers of the United States Geological Survey and by other investigators upon steam boilers. It appears that the transfer of heat to and from a gas is almost entirely by convection, so that anything that is done to increase the commotion or to increase the rate at which the cold gas is removed from the surface and hot gas substituted will increase the rate of heat transmission. If motion is not given to the gas mechanically or by natural gravity circulation, the transfer of heat can only take place by diffusion (conduction), which may be conceived of as a process of gas molecules receiving high velocity from the hot plate and expending it upon slower moving molecules a little distance away from the plate, these in turn passing it on to others. The transfer of heat through gases by diffusion is an exceedingly slow process, as witness the many engineering appliances in which heat insulation is secured by means of "dead-air" spaces.

The success obtained from merely increasing the velocity of the air blowing through the pipe naturally led to the suggestion that the rate of heat transference could be still more increased if the air were churned up and the cold core gas in the center of the pipe brought more positively into contact with the walls. To this end, specially designed "winged' spirals were inserted in

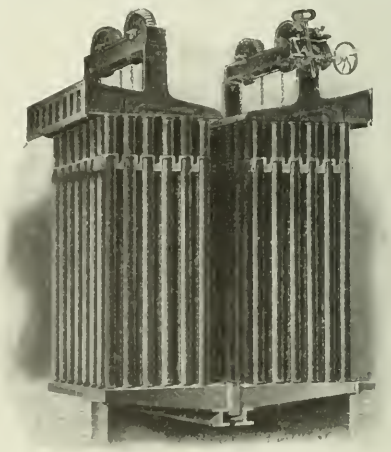


FIG. 2.—66-TUBE AIR HEATER.

the pipe, with results wholly justifying the reasoning, for the rate of heat transfer was increased in about the same ratio as by doubling the velocity of the air.

The results of these experiments are shown in the several curves in Fig. 1, where the line marked 1 shows the heat transmitted per square foot per hour per degree difference of

temperature for various numbers of cubic feet of air passed through the heater per minute. Curve No. 2 shows the same values for the same heater with the same volume of air passed first through one-half and then through the other half of the tubes in series. Curve No. 3 shows the values obtained by passing the air through all the tubes in parallel, but with winged

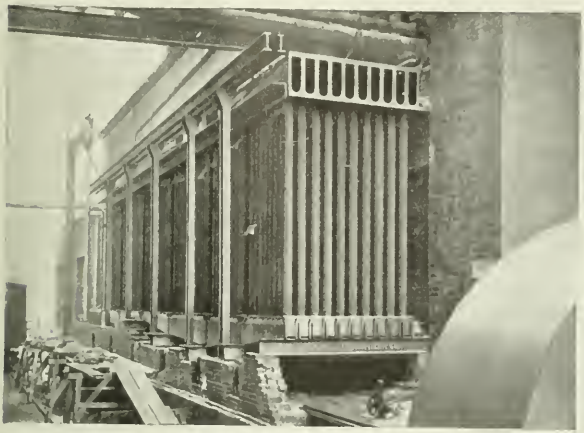


FIG. 3.—GREEN WASTE HEAT AIR HEATER FOR DRYING WORK, 600 PIPES ARRANGED IN THREE PASSES.

spirals in the tubes, while No. 4 shows the values obtained with the spirals and the two groups of tubes in series. Curve 1 in this diagram is especially interesting, since it is nearly a straight line, showing that the rate of heat transmission increases almost directly as the velocity of the air, a result which had already been demonstrated by the United States Geological Survey. In all these experiments the exteriors of the pipes were kept free of soot by means of automatic scrapers similar to those used on the economizer.

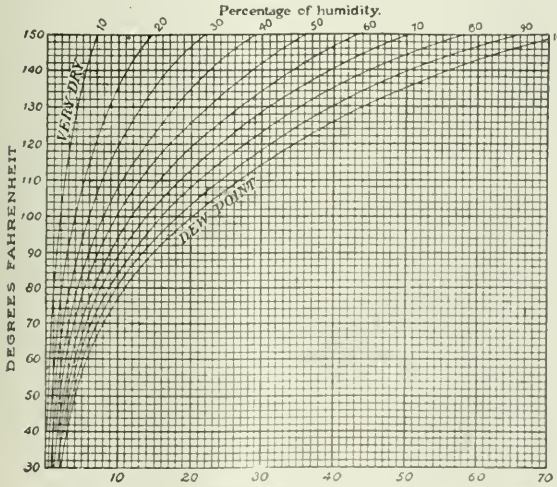


FIG. 4.—RELATION BETWEEN TEMPERATURE OF AIR (DEG. F.) AND GRAINS OF MOISTURE IN AIR PER CUBIC FOOT.

For the above information and the accompanying illustrations we are indebted to the builders of the device, the Green Fuel Economizer Company, of Matteawan, N. Y.

Purification of Water by Ozone.

Dr. S. RIDEAL read recently a paper on the purification of water by ozone before the Royal Sanitary Institute in London.

In view of the bad condition of drinking water in many cities in this country, the subject is interesting.

We take from the London *Electrician* of July 9 the following extracts

The paper deals especially with the operation of the De Frise-Siemens installation for the sterilization of water by ozone at the St. Maur municipal water works of the city of Paris. These municipal water works draw water from the River Marne, a stream which receives a considerable amount of sewage pollution above the intake. This water after being subjected to filtration is further sterilized by ozone.

The plant consists of an efficient arrangement for the production of ozonized air and for its intimate admixture with the water. The current is generated by means of a 45-hp steam engine and a Mordey 110-volt alternator and the voltage is raised by a transformer to 4000 volts. The ozonizers are of the Siemens-Halske type, placed in a dark, cool room.

In Dr. Rideal's experiments there were six of these ozonizers running. The electrical energy required for the production of the ozone averaged 1.31 kw-hours per 104 cu. m. of water sterilized, equal to 57 kw-hours per million gallons. In addition, the energy required for compression, 1.675 kw-hours per 100 cu. m., must be added to the cost, giving a total of 133 kw-hours per million gallons.

M. Colmet Daage, the chief engineer to the Paris municipality, taking 0.11 franc (2.2 cents) as the price per kw-hour (being that charged by the Société de l'Est Parisien), estimates the average cost of treatment at 0.0184 franc (0.37 cent) per cubic meter. He further estimates that for treatment of 300 cu. m. at an electrical cost of 0.055 franc per unit, the expense would only be 0.0072 franc per cubic meter, say two-thirds of a cent per 1000 gal., excluding interest, amortization and repairs.

The ozonized air was introduced laterally into the stream of filtered water in a proportion which was kept constant throughout the run, the volume of filtered water being 104 cu. m. per hour, equal to 22,880 gal., and that of the ozonized air 42 cu. m. per hour (1483 cu ft.) so that the volume of ozonized air supplied averaged 40.4 per cent of the volume of filtered water treated.

The water and air are drawn together by means of an injector into the bottom of a sterilizing tower. This is a vertical cylinder of enameled cast iron constructed in sections and divided at regular intervals by horizontal diaphragms consisting of carefully leveled and finely perforated trays made of celluloid with holes 0.7 mm. (0.026 in.) diameter, whereby the ascending current of gas and water is intimately mixed. In addition the height of the column is sufficient to make the air and water meet under an extra pressure of from 10 lb. to 15 lb. per square inch, which facilitates the absorption of the ozone. The columns are provided at intervals with small glass windows for inspection and with cocks for collecting samples.

The sterilizing effects of this treatment are in every way satisfactory, and it is stated that the Paris municipality has decided to ozonize the whole of its Marne supply at St. Maur, equal to 90,000 cu. m. per day. The water to be treated will pass through the existing filters at twice the present rate, 16 ft. instead of 8 ft. per 24 hours. An ozone installation capa-

ity of treating 10,000,000 gal. a day (half the above quantity) by the system described in this paper will be erected at St. Maur, involving no further delay for storage or filters. The whole of the water passing through the filters, whatever its coli content, will be ozonized at an expenditure of 315 kw-hours per million gallons.

The author's general conclusions are "that (1) the ozone treatment of filtered river water as carried out at St. Maur, Paris, by the De Frise process is a satisfactory method of insuring a standard of purification for a municipal water supply equal to modern requirements. (2) The De Frise process differs from all previous attempts at water sterilization by means of ozone in combining the De Frise sterilizer and ozone recuperation system with the Siemens-De Frise ozonizer, which combination avoids the difficulties attending the use of the emulsifiers and sprayers which have been hitherto used for this purpose and is attended with a low cost for renewals owing to breakages in the dielectric.

Portable Electric Pyrometer.

The Wm. H. Bristol electric pyrometers have become well known in many processes where temperatures lower than 2000 deg. are used. These pyrometers have been made in both switchboard and portable form to indicate or record high temperatures, but most of the instruments now in service are for ranges of temperature lower than 2000 deg. Fahr. There are quite a number of processes in which excessively high temperatures are used and these temperatures should be measured intermittently in order to make control possible and to obtain a uniform product. In experimental work temperatures in the neighborhood of 2500 deg. Fahr. should often be measured, as for instance in boiler tests where the boiler furnace temperature is to be determined.

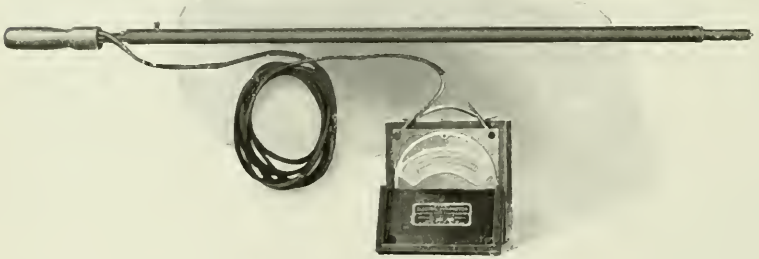


FIG. 1.—PORTABLE THERMO-ELECTRIC PYROMETER.

A new quick-reading form of the Wm. H. Bristol pyrometers has been designed and preliminary models tested in actual service in several different processes where the temperatures are excessively high and the requirements very severe. This special pyrometer consists of a patented compound thermo-electric couple used in connection with a special portable instrument equipped with a pivot jewel-bearing Weston movement. The complete outfit is shown in Fig. 1.

The thermo-electric couple is shown externally in Fig. 2. Fig. 1 shows the couple with the protecting sheath pulled back against a stop leaving the tip of the thermo-couple exposed. When a reading is to be taken with this special thermo-couple it is inserted into the furnace or kiln, as shown in Fig. 2, with the tip protected from mechanical injury and as soon as the couple has been inserted at the proper point in the kiln the iron pipe protecting sheath is slipped back so that the tip is exposed to the hot gases whose temperature is to be measured. After a reading has been taken the couple should be quickly withdrawn and partially cooled off before another reading is taken.

This form of couple is the invention of Prof. Wm. H. Bristol, formerly of Stevens Institute and now president of the Bristol Company. United States patents were issued July 5, 1904, and August 29, 1905. The compound construction of this couple is shown in Fig. 3. The point *A* corresponds to the regular junction of an ordinary thermo-couple and the two elements which join at the point *A* are platinum and platinum-rhodium, this being the particular couple selected as a standard by the German Reichsanstalt. The platinum, platinum-rhodium elements extend to the points *B* and *C*, where they are welded to two other wires made of inexpensive alloys which are such that the electro-motive forces generated at *B* and *C* are practically equal and opposed when these junctions are both exposed to temperatures not higher than 1200 deg. Fahr. These inexpensive alloy elements are extended to the point *D*, which is the cold end of the couple.

FIG. 2.—THERMO ELECTRIC COUPLE.

This construction of the quick-reading couple is such that the platinum-rhodium tip of the couple *A* may be exposed to excessively high temperatures up to 3000 deg. Fahr. without the temperature of the junctions *B* and *C* exceeding a safe limit. The temperature at *A* may be quickly measured with this special couple as the platinum-rhodium tip is exposed directly to the hot gases in furnace or kiln. In this way an inexpensive substitute is provided for the expensive platinum-rhodium couples previously employed for the measurement of such high temperatures.

This quick-reading form of the Wm. H. Bristol electric pyrometers with the compound couple has been tested under very severe conditions and found extremely valuable for such applications as brick kiln temperatures, boiler-furnace fire-box temperatures, by-product coke-oven combustion flue temperatures, soaking pit temperatures, etc. The complete outfit is portable and readings of temperatures in the neighborhood of 2500 deg. Fahr. may be obtained in a very few seconds after inserting the tip of the couple to the point where the temperature is to be measured. By using a special form of the platinum, platinum-rhodium tip this type of thermo-couple can be used to measure the temperature of red hot surfaces of metal or other material.

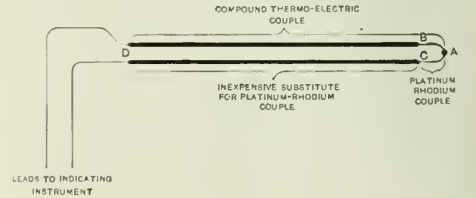


FIG. 3.—COMPOUND CONSTRUCTION OF COUPLE.

Notes.

Dr. **John E. Teeple**, consulting chemist and chemical engineer, Hudson Terminal, 50 Chuch Street, New York, announces his complete recovery from the illness which has interrupted his work for several months.

The **Crocker-Wheeler Co.** announce that on or about Sept. 10 they will open an office in the Ford Building, Detroit, Mich., in charge of Mr. Charles W. Cross.

Mr. **Wm. H. Lindsey**, of Nashville, Tenn., has been elected vice-president of the Napier Iron Works, the Crescent Coal Company and the Dealers' Fuel Company. Mr. Lindsey is prominently identified with the American Cyanamide Company and large water-power interests in the South.

Metal Corrosion and Protection.—The Carnegie Library of Pittsburgh has sent us the second revised and enlarged edition of their list of references to books and magazine articles on metal corrosion and protection. This is a very useful work. The price is 10 cents, postpaid.

Iron and Steel Institute.—The autumn meeting will be held in London from Sept. 27 to Oct. 1.

American Electrochemical Society.—The autumn meeting will be held in New York from Oct. 28 to 30.

Fixation of Atmospheric Nitrogen.—With respect to the question of working dilute nitrogen oxide gases into a more concentrated marketable product, we notice the recent (British) patent 8426 of Aug. 5, 1909, of the Allgemeine Elek. Ges. in the Lond. *Elec. Eng'ing*, of Aug. 12. The treated air, some 2 to 4 per cent of NO, after being passed through the oxidation chambers where the NO is converted to NO_2, is passed through apparatus containing weak basic oxides of zinc, copper, or lead. When all the oxides of nitrogen are absorbed, the salts are slowly heated in iron retorts to a temperature of 500 deg. C. The oxides are given off in the form of pure peroxide of nitrogen which is then converted in water towers to 40 per cent commercial acid, or condensed as peroxide of nitrogen. If the heating of the salts is performed in a vacuum, a much lower temperature is required.

Evaporators.—"Castings for the Sugar Industry and the Chemical Trades" is the title of a booklet treating of vacuum pans, multiple effect evaporators, distillers, defecators, rosin stills, soda kettles and similar apparatus, together with surface, jet and barometric condensers, wet and dry vacuum pumps, cooling towers, centrifugal pumps, and other vacuum apparatus manufactured by the Wheeler Condenser & Engineering Company, of Carteret, N. J. The booklet is quite handsomely illustrated.

A New Aluminium Syndicate.—According to the London *Electrical Review* of July 30, the first practical step in connection with the proposed revival of the international aluminium syndicate has been taken, by the arrival at a complete agreement of the representatives of the French producers at a conference held in Paris on July 19. It is now intended to approach the Aluminium Industry Company of Neuhausen with the object of coming to a fresh understanding, which, if concluded, will probably foreshadow the re-establishment of the syndicate. The Paris conference was the second of the kind. The announcement of the first conference has already led to considerable dealings, on the one hand, in the shares of the Swiss company at Zurich, which advanced by 10 per cent in the four days ending with July 16, while a further rise is mentioned in a report from Manheim to the effect that the German merchants have just raised the price of aluminium by 1 to 1¼ cents to 16 cents per pound. It is not known for the moment whether the French companies have yet made any advance in the price of the metal, but it is understood that the demand has grown in recent months, whereas a sudden decline took place in 1907 and continued during 1908, although it has to be borne in mind that the productive capacity of various countries has been largely increased in the past two years. The stocks of the two French companies are reported to have been cleared, and apparent confirmation of the expansion in requirements is shown by the circumstance that the exports of aluminium from France in the first five months of this year amounted to 617 tons, as compared with only 126 tons in the equivalent period in 1908.

Digest of U. S. Patents

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC FURNACES (*Continued*).

618,391, Jan. 31, 1899. Hugues Bovy, of Geneva, Switzerland. Resistance type. Designed for production of calcium carbide. The furnace comprises an open-topped upper casing insulated by bricks from a lower casing filled with a layer of subdivided carbon on which rests a series of carbon blocks separated by carbon powder held in place by carbon plates. Over each block is an electrode, these upper electrodes being surrounded by the material to be treated. Direct, or monophase or polyphase alternating electric current may be used, the current passing through the upper electrodes to the carbon blocks, which become incandescent. The vapors produced at these points of maximum heat pass upward through the molten material, stir it and distribute the heat.

618,703, Jan. 31, 1899, Hiram Stevens Maxim, of London, England.

Arc type. Designed for manufacture of "diamond carbon." The furnace consists of a strong steel shell lined with bricks of compressed silica or magnesia. Carbon electrodes secured to water-cooled holders pass through strong upper and lower heads. The furnace may have an interior water-cooled lining. The upper electrode is adjustable and the upper head may be formed with interrupted screw threads. A hydrocarbon, such as gasolene, and carbon dioxide in a solid or snow-like condition is placed in the furnace. The carbonic dioxide is, by the heat of the arc converted into carbon monoxide, thereby creating very high pressure. The carbon in immediate contact with electrodes is converted into "diamond scales," which have high electrical resistance, and may be used to, when powdered and mixed with tar, pitch or sugar, be molded into lamp filaments. Furnace may be used for any purpose requiring high temperatures and pressures.

625,252, May 16, 1899, Hillary Eldridge, Daniel Johnson Clark, and Sylvain Blum, of Galveston, Tex.

Arc type. Designed for production of calcium carbide and illuminating gas. Fire brick structure with open-topped furnace chamber in upper portion. The sectional cathode of metal is located in bottom of chamber. A counterweighted fume-collecting hood is mounted over furnace, the counterweighted anode depending therethrough and insulated therefrom. A rotatable plate carrying a stirrer or plow is mounted on ball bearings on the upper rim of the furnace. Two annular concentric pipe coils, the outer one for air, and the inner for gas, surround the charge. The heat of the arc reduces material, the heated air is conducted to a carburetor, and the gas is fixed in the inner coil.

625,918, May 30, 1899, Ernest Bailey, George Reeve Cox, and Walter Thomas Hey, of York, England.

Arc type. Designed for production of white lead. A closed pot for melting lead is mounted over a furnace. Depending through the pot cover is a perforated adjustable carbon electrode, mounted in an insulated bridge. Through a pipe passing through the electrode is supplied a mixture of steam, carbonic acid, and acetic acid vapors, which is projected against the molten lead and combines with the lead volatilized by the arc to form white lead, which is collected in flannel bags. The melting pot is the positive pole of the circuit.

628,373, July 4, 1899, Frank P. Van Denbergh, of Buffalo, N. Y.

Arc type. Designed for reduction of ores, typical processes being production of phosphoric acid from apatite, sulphuric acid from gypsum, reduction of cinnabar ores or alkaline chlorides and bromides. The closed furnace of refractory material has a lower portion, for containing fused material, of less diameter than upper chamber, through whose side walls project longitudinally adjustable electrodes carried in and insulated from swiveled or ball and socket bearings, made gas tight. The charge is fed through the roof by a mechanical feeder, from a double-valved hopper, into the arc. Gases escape through a pipe to a condensing chamber. Molten material discharges continuously through an upwardly extending duct in the wall of the furnace, so that level of molten material in the crucible is maintained constant The bottom of the crucible is removable

NEW BOOKS.

Rose, T. Kirke. The precious metals; comprising gold, silver and platinum. 311 pages, illustrated. Cloth, $2 net. New York: D. Van Nostrand Company.

Metal Corrosion and Protection. (A very full reference list of books, articles and papers on this subject, with a brief note on the contents of each article, etc.) 64 pages. 10 cents. Pittsburgh: Carnegie Library.

Groth, L. A. Welding and cutting of metals by aid of gases or electricity. 280 pages, illustrated. Cloth, $3 net. New York: D. Van Nostrand Company.

Holley, Clifford Dyer. The lead and zinc pigments. 359 pages. Cloth, $3 net. New York: John Wiley & Sons.

Kemble, W., Fritz and Underhill, C. Reginald. The periodic law and the hydrogen spectrum. 16 p. fold. diagrs. Cloth, 50 cents. New York: D. Van Nostrand Company.

Crane, Walter R. Index of mining engineering literature; comprising an index of mining, metallurgical, civil, mechanical, electrical and chemical engineering subjects as related to mining engineering. 824 pages. Cloth, $4 net. Mor., $5 net. New York: John Wiley & Sons.

Tracy, J. Clayton. Exercises in surveying for field work and office work; with questions for discussion; intended for use in connection with the author's book, "Plane Surveying." 183 pages. Cloth, $1 net. New York: John Wiley & Sons.

Clerk, Dugald. The gas, petrol and oil engine, v. 1. General principles of the internal-combustion engine, together with historical sketch. New ed. revised and enlarged. 369 pages. Cloth, $4 net. New York: John Wiley & Sons.

Houghton, C. Edwin. The elements of mechanics of materials: a text for students in engineering courses. 194 pages, illustrated. Cloth, $4.50 net. New York: D. Van Nostrand Company.

BOOK REVIEWS.

Through the Yukon and Alaska. By T. A. Rickard. 392 pages, 175 illustrations, indexed. Price, $2.50. San Francisco: Mining & Scientific Press.

Another book of the "new kind" inaugurated by T. A. Rickard, a "mining and metallurgical journey" up to date. The title page is in imitation script, the first chapter a series of paragraph sketches about the Inland Sea in artistic prose: the second chapter a picturesque statement of the history of the country and its development as related to its topography, and so on throughout the book skillful word painting is linked with scientific observations in a truly original and most effective manner.

A particular feature of high value and withal extremely attractive is the striking and beautiful illustrations, many of them worth looking at more than twice. The combination of fine description, splendid photographs, and accurate information—geographic, mining, metallurgic, and economic—makes altogether a notable book to be highly recommended to so many classes of people that we might as well say right at once—to everybody.

* * *

Die Electrochemischen Verfahren der chemischen Gross-Industrie. Vol. 1. Electrometallurgy of aqueous solutions. By Dr. Jean Billiter, privatdocent at the University of Vienna. 284 pages, 117 illustrations, no index. Price, 12 marks. (Retail price in New York, $4). Halle a. S., Wilhelm Knapp.

This is the first volume of an ambitious work, the four volumes of which are to be: Electrometallurgy of aqueous solutions, electrolysis of aqueous solutions with insoluble anodes, electrolysis of molten salts, and electric furnaces. The object is to give a description of the present status of these industries, discussing along with the description the scientific and technical principles involved in the operations.

The introduction presumes to give a short account of modern electrochemical principles and theory. The presumption is false, for the author literally does not know what he presumes to be talking about. He wofully misstates Faraday's law, confounding gram-equivalents with gram-ions, and chemical equivalents with atomic weights and with electrochemical equivalents. All users of this book are advised to skip this chapter and to get their fundamental electrochemical theory and principles from other and more trustworthy sources.

The book describes and discusses the electrolytic refining of copper, silver, gold, lead, zinc, tin, nickel, bismuth and cadmium. The attempt to apply the formulas of ionic concentration, etc., to practical data results in many misfits, practical *impasses*, and very few illuminating explanations. The descriptions of industrial processes are good and fairly well illustrated. They offer, however, little of value not to be found in other existing treatises.

* * *

Annuario della Industria Mineraria, Metallurgica e Chimica Italiana. Second year, 1909. Duodecimo, 580 pages. Price, 10 lire. (Retail price in New York, $2.65.) Turin: G. U. Cassone.

An annual with characteristics different from those in German, French or English. Over half the book is filled with the existing laws, rules and regulations affecting the mining, metallurgical and chemical industries in the various provinces of Italy. The second section concerns the government bureaus, schools and scientific societies controlling or active in these industries. This is supplemented with a very well compiled list, with addresses, of some 1600 prominent Italians in these lines; also obituary notices for 1909 (including the well-known Vincenzo Spirek). The section following gives a list of all the mines in Italy, classified according to the ores worked, and giving names of the operating companies. The concluding chapter has miscellaneous tables, rather desultory in content, and gives the Italian production of ores, metals and chemical products for 1906 and 1907.

We have noted in the above review the information contained in the book most likely to make it valuable to the reader outside of Italy.

* * *

Elementary Chemistry. By F. B. Emery, A. M., McKinley High School, St. Louis, Mo. 666 pages, 191 illustrations, 36-page index. Price, $1.50. Easton, Pa.: The Chemical Publishing Company.

A marvellously cheap book, from the printer's and publisher's standpoint, and a rattling good chemistry for the beginner to start on. It has many novel features, but it has all the old-fashioned virtues. The author is sound in his principles and has worked them out successfully.

It is many years since the reviewer has seen a book on elementary chemistry which he would recommend as warmly and as unreservedly as this one.

Electrochemical and Metallurgical Industry

VOL. VII. NEW YORK, OCTOBER, 1909 No. 10

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH.D.....*President*
E. F. ROEBER, PH.D.....*Editor and Secretary*
C. E. WHITTLESEY.....*Treasurer*

Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, OCTOBER, 1909.

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Bayonne as an Industrial Centre.

At the coming convention of the American Electrochemical Society one whole day—Friday, Oct. 29—will be devoted to an excursion to the city of Bayonne, N. J. From an engineering point of view, Bayonne is a most interesting "melting pot," to borrow Mr. Zangwill's phrase. In the Constable Hook section there are the big oil refineries, borax works, nickel works, and sulphuric acid works, with an interesting new briquetting plant. In the long string of works in the Newark Bay section, the manufacture comprises such varied products as boilers, submarine cables, electric launches, motors, oxy-acetylene welding apparatus, sulphur refining, extraction of fixed oils, manufacture of essential oils, etc. A goodly number of these works will open their doors to the Society, and the excursion should prove exceedingly interesting and instructive.

Electrode Losses and Furnace Efficiency.

Mr. Carl Hering's interesting article in this issue will undoubtedly take an important and permanent place in the literature on the theory of electric furnaces. It brings the theoretical side of the laws of electrode losses into fairly satisfactory shape under the simplifying assumptions that the condition of operation is stationary (the temperature at any point remaining constant in time) and that no heat is given off from the electrode to the surrounding walls. Under these conditions it is always true that the heat passing from the furnace interior into the electrode can be written $H - \frac{1}{2} i^2 r$; and the heat passing from the outer end of the electrode into the cooling water $H + \frac{1}{2} i^2 r$. This is evident because the difference between these two quantities of heat must be just the total Joulean heat $i^2 r$ generated in the electrode. It is also easy to argue that H must be the heat which would flow from the hot inside to the cold outside if there was no electric current passing. We have thus a simple superposition of two phenomena, firstly, simple heat conduction H (as though there was no current flowing) and secondly, generation of heat from electrical energy within the electrode, this heat tending impartially to flow one half to the outside and one half to the inside (as though there was no heat conduction otherwise). This seems all very simple, but the difficulty of the whole problem is due to the fact that the temperature and with it the electric and thermal conductivities of the electrode material change from point to point. What "mean" thermal conductivity shall we choose in the calculation of the simple heat conduction H as sketched above? Nor does Mr. Hering's analysis help over this difficulty. His fundamental differential equation on page 443 is strictly correct. But in integrating it—equations (3) and (4)—he silently assumes σ and k to be constant. Nevertheless the results, as found by Mr. Hering, represent a fair first approximation to the truth—undoubtedly the best we have at present.

* * *

The second part of Mr. Hering's article shows how, on the

basis of this theory, it is always possible to find a "best" value of the ratio of cross-section to length of electrode; this best value corresponding to minimum electrode loss. Theoretically it must be said that minimum electrode loss is not identical with maximum furnace efficiency; the best value of the ratio for maximum efficiency is represented by a more unwieldy formula than Mr. Hering's very simple formula (22) for minimum electrode losses. But for large furnace capacities both formulas become the same. If arguing further on this point we might drive a nice theoretical point a little too far, in view of the difficulty of practically applying even such a simple and handy formula as Mr. Hering's (22). The difficulty is that there is very few exact data published on the fundamental constants of heat and electric conductivities at high temperatures. On the basis of those that are available, Mr. Hering makes a very courageous and interesting calculation for graphite and carbon. However, as this whole subject will be discussed in several papers at the coming convention of the American Electrochemical Society, we defer further comment until that time, and meanwhile recommend Mr. Hering's paper to the careful attention of everybody interested in electric-furnace design.

Uniform Nomenclature of Iron and Steel.

The report of Committee 24 at the recent Congress at Copenhagen (described at length elsewhere) recalls similar attempts in the same direction, dating back to the first Commission's report at the Centennial Exhibition, in 1876. That first Committee was truly representative and international in character, and its report was the result of much careful deliberation, but it fell flat, and scarcely one of its recommendations has passed into commercial or scientific use. A similar fate awaits the 1909 report, which is less carefully considered and more faulty than the first. The simple fact is that all such reports, elaborated along the lines adopted, are doomed to failure because conceived upon wrong principles. As far as their practical influence extends or will extend, such as have been made and such as will be made upon a similar plan of procedure, are scarcely worth the paper they are printed upon, certainly not worth the time and trouble which are expended upon them. The false principle involved is that of allowing the iron and steel industry to bring forth new commercial products and to name them and sell them as "such and such" according to the most illogical or nonsensical exigencies of commerce, and then some years later stepping in to reform the errors when it has become forever too late. Commercial designations once fixed, no matter how unsuitable or unscientific, are next to impossible of correction. The committees studying this question of a uniform and consistent nomenclature have been limited in their activity either to describing a confusion which they were powerless to straighten out, or to proposing reforms which they were incapable of enforcing.

* * *

The question is then to be considered, as to whether some reform, some plan of uniform nomenclature, some principle of procedure, is at all feasible. We are sure that there is a possibility of improving upon the present status, and of doing it with reasonable satisfaction to all concerned. But the reform must proceed upon different principles from those of the aforementioned committees or commissions. First: The fact must be recognized that names and designations in commercial use are practically fixtures, and attempts should be made to define them or to substitute others only where the name is so utterly false and misleading as to lend itself to misrepresentation and fraud. The commercial world will then recognize a vital reason for the proposed reform and will be likely to accept it. The proposed nomenclatures have been fundamentally faulty in that they recommended changes upon other grounds than the above-described necessity, and the commercial world has simply ignored the recommendations. Second: Having made a foundation by accepting the bulk of the existing commercial nomenclature, and having proposed revisions of only such as commerce will recognize the absolute necessity of changing, the next and most promising principle of action is to provide the machinery by which new commercial products can receive proper names as soon as they appear. To put the matter in other words, it means to establish a bureau of registration of births, with the proper officials to provide a suitable name and to give the youngster official and orthodox baptism. Once such machinery is put into active operation, the hit-or-miss naming of new products, the nicknaming instead of regular baptism, may become a thing of the past, and a systematic uniform nomenclature gradually evolve in the place of the present chaos. It is a fact that many new and valuable commercial varieties of iron and steel have been on the market for years before any authoritative commission recommended names for them (we may mention mild steel and electric steel as examples), and here is the weak spot of the whole question.

* * *

To put an end to the present unsatisfactory conditions, and to provide the machinery for building up a proper nomenclature upon sound principles of action, we make the following proposition, which we recommend to the parties most concerned: Let the American Institute of Mining Engineers, the Iron and Steel Institute of Great Britain, Verein Deutscher Eisenhüttenleute, Jern Kontoret of Sweden, Comité des Forges de France and International Association for Testing Materials each appoint one member of an international committee, each member being appointed for one year, so as to provide against too great fixity in the personnel of the committee, and such committee to be permanent. Its functions will be to recommend such changes in existing nomenclature as it deems absolutely necessary for guarding against commercial dishonesty, but further, and, much more importantly, to recommend suitable and correct names for new commercial products as soon as they appear. Its recommendations would be recognized as binding upon the concurring societies, and could undoubtedly soon gain such weight as to obtain government sanction and adoption in all countries where the above societies possess influence—i.e., in all civilized countries. The above proposal is not destructive; it is intended to be reformatory to only a minor and absolutely necessary extent; its chief function is to be preventative of future confusion and to be eminently constructive in its application. One society must take the initiative. Will not the American Institute of Mining Engineers appoint its member of this commission, and invite severally the other five to appoint theirs? Let us apply the principles of preventive medicine to the matter, and not be forever dosing the sick man whom we have allowed to get sick, or making post mortems.

Raw Materials and Finished Products in the Iron and Steel Industry.

In its recovery from the recent depression the iron and steel trade finds itself at about the same chronological stage as was reached early in 1905 after the 1903-4 depression. The existing capacity is about equally well employed, while in a general way the recovery in the average level has proceeded by about the same amount as at the earlier time. There have been many points of similarity between the depressions of 1903-4 and 1908-9. As to time, they were of about equal duration, while in each case there was a partial maintenance of finished steel prices, with a wide-open pig-iron market, followed by a break in steel prices, followed quickly by a recovery in which pig iron joined. The points of dissimilarity were relatively minor. In 1903 pig-iron production began to decline in midsummer, and declined gradually for a few months and then rapidly. In 1907 maximum production was reached in October, and the decrease in production in less than three months exceeded 50 per cent. In 1903 pig-iron prices declined steadily through the year; in 1907 the decline began in midsummer, so that in each case prices began to decline a few months before production began to decline. In finished products some prices broke late in 1903, while a few did not break until September, 1904. In the later period prices were more uniformly held, there being no serious breaks until the period Feb. 18 to May 1. In the earlier period the recovery in pig-iron prices started in July, 1904, and the recovery in finished products started in October. In the later period prices of both pig iron and finished products began to recover in May.

* * *

The recovery accomplished in 1904 and the early part of 1905, the iron and steel trade was continuously prosperous until late in 1907. The trade has again recovered, but for how long its prosperity will continue is for the future to decide. From the above and other comparisons that might be made, it seems fair to take the early part of March, 1905, as the time in the previous recovery corresponding chronologically with the present in this recovery. Prices compare as follows:

	March 1, 1905.	Oct. 1, 1909.
Mesabi Bessemer ore	$3.50	$4.25
Mesabi non-Bessemer ore	3.00	3.50
Connellsville furnace coke	2.25	2.75
Bessemer pig iron, valley	15.50	18.00
No. 2 foundry iron, Birmingham	13.50	14.50
Steel billets	23.50	26.00
Rails	28.00	28.00
Plates	1.60	1.50
Shapes	1.60	1.50
Steel bars	1.50	1.40
Sheets, 28 gage	2.25	2.20
Plain wire	1.65	1.60

Rails stand at the same price at each date. All cruder materials are at higher prices now than on March 1, 1905, while finished products are at a lower level all along the line. The table enumerates the principal finished steel products. Other products would presumably show the same relation.

* * *

In the case of Lake Superior ore the difference is really greater than appears in the comparison. For March 1, 1905, we give prices for the season 1905, representing an advance over the season of 1904 of 75 cents on Bessemer and 65 cents on non-Bessemer ores, whereas for the present date we give prices for the season just ending, when there are clear prospects that for the season of 1910 there will be an advance of 50 cents. While the table shows an advance of 50 to 75 cents, the spirit of the situation represents more than $1. Connellsville coke shows an advance of 50 cents, Bessemer pig iron an advance of $2.50 and Southern pig iron an advance of $1. What is the rationale of this departure in the relation between crude and finished products? Some may answer that finished steel prices broke violently in the fore part of the year, after a long period of price maintenance, while coke and pig-iron prices had been subject to market adjustment all through 1908, and that it is therefore natural that finished steel prices should be slower in recovery. We do not concur. Shorn of the by-play, the recent movement to maintain prices was not greatly different from that in the earlier period. Granting, however, that the break was more violent, why should not the rebound be sharper? Why should coke and pig iron, which had comfortably settled to bottom more than once, advance so rapidly? Others will probably answer that this is a period of readjustment, and comparisons should not be carried too far. We are not carrying the comparison far; it requires no hair splitting to develop from the table that crude and finished products are in widely distinct classes as to the price movement. It is too much to charge to accident.

* * *

A scrutiny of conditions in the branches of the industry involved readily discloses reasons for the difference. Lake Superior iron ores have come to be tightly held and the owners are in position to charge prices which present conditions justify. Connellsville coking coal lands are not so tightly held; ownership is fairly well distributed, and severe competition has appeared on occasion, but at the present rate of exhaustion the life of the region promises to be 30 years or less, while many of the operations have but a few years before them. Pig iron is naturally higher when its direct raw materials are higher; Southern iron, while produced in a distinct region, is marketed largely where Northern raw material conditions dictate prices. With lower prices for finished products, the industry is paying greater tribute to the raw material. Lake Superior ore and Connellsville coke are the best materials which have been found in the United States, but the relative prices paid for them have been getting higher and higher. A spirit of restlessness has appeared in recent years, and by-product coke and Cuban ores, by way of instance, have been sought. This spirit of restlessness is destined to increase. In point of tonnage it has produced comparatively little of result thus far, but the expansion has really been hampered by the great expansion in demand for finished product ready for use. There has been little time afforded for investigation and exploitation of minerals, and the introduction of new processes or modifications for the use of new minerals. It has been necessary to double pig-iron production every 10 years, and the growth in tonnage, with its wonderful achievements in the handling of materials, has far exceeded the improvement in metallurgical methods. There is good reason to believe that conditions will be different in the next decade or two, and that while tonnage will continue to increase and the mechanics of manipulation will continue to improve, more important forward steps will be taken in metallurgical processes for the adaptation of less convenient raw materials than Lake Superior ore and Connellsville coke

Fifth International Congress for Testing Materials.

(From Our Special Correspondent)

Copenhagen was the place chosen for this fifth congress, and a very happy choice it proved to be. Somewhat out of the beaten tracks, the capital of Denmark was proud to act the host, and the Congress would certainly have completely monopolized the attention of the Danes, had not Dr. Cook, of North Pole fame, arrived almost simultaneously with the Congress and shared public attention with it.

At the opening ceremonies in the Aula of the University, at 9 a. m., Sept. 7, the Congress was honored by the attendance of the King and Queen of Denmark, while the Crown-Prince was present as honorary president of the Congress. Some 30 Governments were officially represented, and the beautifully decorated hall, full-dress assemblage, picturesque costumes and uniforms of foreign delegates and military, made a most impressive *ensemble*. President Foss opened the exercises, the Crown Prince responded, and Mr. Paul Larsen, of Copenhagen, then read, most inopportunely, a long technical paper on the development of the Danish cement industry—a communication which should have been presented at one of the section meetings and there read *by title* only.

The business of the Congress was conducted in three sections: (A) Metals and metallography; (B) Cement and concrete, (C) Various materials. These sections met on the mornings and early afternoons of Sept. 8, 9 and 10, while the rest of the afternoons were given over to excursions and the evenings to entertainments; for instance, excursions to the Royal Porcelain Works, Polytechnic Academy, State Testing Laboratory, etc., and later opera at the Royal Theatre, reception by the Mayor and City Council in the Town Hall—a most brilliant affair.

Coming to the work of the Congress, Section A (metals) was most comfortably and even luxuriously installed in the council chamber of the City Hall. Sections B and C had to content themselves with much less comfortable and restricted quarters in the basement of the same building; it may be remarked with truth and candor that these two sections held their meetings under difficulties. The papers of Section A were divided under the headings: Metallography, hardness tests, impact tests, alternating stress tests, tests of cast iron, influence of temperature on mechanical properties of metals, magnetic and electric properties of metals, internal strains, reports of committees. Section B divided its communications into: Reinforced concrete, methods of testing, action of sea water on cement, weathering resistance of building stones, various reports. Section C had communications upon: Oils, rubber, wood, protective coatings for metallic structures, paper, general regulations for international tests.

Among the numerous papers presented there were not many which attracted great attention. Your correspondent limited his attention to the proceedings of Section A, and can therefore report personally only thereupon.

The report of Professor Heyn upon the progress of metallography from 1906 to 1909 was severely criticised by English, French, and Americans, as very incompletely representing the progress made in their respective countries, and protest was made against printing it in the proceedings of the congress without many necessary additions.

The report of the Committee for the Establishment of International Specifications for Iron and Steel, presented by Dr. Rieppel, was vigorously attacked by Leon Guillet, of Paris, and as vigorously defended by Professor Heyn, of Charlottenburg. It looked for a time as if the matter would become a Franco-German squabble, but outsiders gradually took part in the discussion and Professors Heyn and Guillet finally retired to adjust their differences, which was happily accomplished. Professor Webster, of the University of Pennsylvania, took part vigorously on behalf of the American members, and the report was finally laid on the table and the committee requested to continue its labors.

Somewhat similarly, the report of the committee on the uniform nomenclature of iron and steel was attacked to such an extent that it was finally referred back to the committee with instructions to consult, and if possible agree, with national scientific societies before handing in a revised report to the next congress. Prof. H. M. Howe, chairman, was not present to defend the report, which was vigorously criticised. Messrs. Pourcel and Greiner presented a printed protest against the proposed definition of "steel," others criticised the proposed metallographic terms and definitions. Prof. J. W. Richards, of Lehigh University, criticised the report for some erroneous definitions, some inexcusable omissions, and finally as being based on a faulty principle which could never lead to any practical results or acceptable conclusions. The report was referred back to the committee for improvement and revision.

Abstracts of some papers and reports will be found in the Synopsis in this issue. Before closing, we would remark on the futility of attempting at an International Congress to put the papers and discussions into two or three languages. As far as discussions are concerned, proper statement in either French, German or English, in the speaker's own tongue, should be and is, in reality, sufficient; the attempt to put what is thus said into another of these three languages is in 9 cases out of 10 a flat failure and a sheer waste of valuable time. The printing, in a hurry, of a paper in three languages is also a disappointment and a failure. The translations are usually miserably done, by incompetent persons, and the result is confusion and a waste of good ink and paper. One example will illustrate this point sufficiently well: A small electric furnace was described, the outer case of which was a section of terra-cotta drain or sewer pipe. The translator (*sic*) spoke of this section of pipe, throughout the description, as a "cesspool." We beg pardon of our readers for such a coarse reference, but the disgust provoked is paralleled by our impatience at the inanimity of attempting translations under such circumstances. We would most strongly recommend to the authorities of future similar Congresses, that the translation be always carefully read in manuscript or proof by a competent person who reads it as his mother tongue. Only in that way can false syntax, awkward expressions and mistranslations be satisfactorily avoided.

The Iron and Steel Market.

Instead of moderating its pace as prices have been reached more nearly approaching what the experience of recent years would indicate as normal, the iron and steel market has advanced more rapidly. In the past month the trade has accepted the conclusion that a genuine bull movement is on and speculation is rife as to how long the improvement will last. Conditions appear to be such as to promise a continuance of rising, or at least firm, prices for six months at least, with increasing tonnage. It has sometimes been said that the iron trade can never look more than six or nine months ahead, so that prospects are really as favorable as could be expected at any time.

Specifications on old contracts for finished steel products continue at an entirely satisfactory rate, while the volume of new buying has been increasing, the combined result being to book mills farther and farther ahead.

Prices of some finished steel products advanced during September, steel bars $1 a ton to $1.40, Pittsburgh, and plates and shapes $2 a ton to $2.50, Pittsburgh. Sheets have shown a firmer tone, mills being less disposed to contract far ahead at current prices. Premiums on tin plate for early delivery almost disappeared, but that was due to the close of the period calling for the heaviest deliveries, prospects for a general advance for next year's deliveries increasing. Wire products have been uninteresting, being practically out of season. Steel pipe did not experience the expected advance, and it is now rather late in the season to expect one. Wrought-iron pipe, however, was advanced one point, or $2 a net ton, to a basis six points above

steel pipe. Railroad spikes have strengthened, to $1.70, and an advance is expected for next year's delivery. Rail buying for 1910 delivery has been moderately large, and output promises to be larger than in the current year, although possibly not reaching the record tonnage made in 1906.

An interesting and rather unexpected feature in this general upward movement is that the cruder materials have advanced to a higher level, proportionate to finished steel products, than was the case in the recovery, in 1904-5, from the depression of 1903. With finished steel products at a materially lower average level than prevailed during the first half of 1905, pig iron and coke are at a materially higher level than in that period. Lake Superior ore, of course, has not changed in price, being at the 50-cent reduction made for the season of 1908, but is higher than in 1905 or even in 1906, and it seems to be accepted that a 50-cent advance will be made for next season.

The three years 1905-6-7 formed a period of sustained demand for steel products, with prices slightly advancing. As noted, even the prices early in 1905 were higher than those now ruling, yet it was not until August, 1906, that Bessemer pig iron reached the level now prevailing, the average price in 1905 being $2.50 below to-day's market. Connellsville coke makes a similar showing, and, as noted, Lake Superior ore does likewise.

Pig Iron.

Bessemer pig iron has led the market in the Central West, with sales to this writing in excess of 125,000 tons and a few closing days of the month still to be heard from, while the price advanced from $16.75, valley, to $18. The chief buyers were the Jones & Laughlin Steel Company, Republic Iron & Steel Company, Lackawanna Steel Company and Youngstown Sheet & Tube Company. Having a large production of their own, these interests only buy when their steel plants are running very full. Deliveries in all these cases were for this year, but some minor purchases have been made for next year. The movement in basic iron has been comparatively light, and it can be quoted nominally at a dollar under Bessemer. Foundry iron in the valleys advanced under the lead of Bessemer to $16.50, valley, for this year, and $17 to $17.50 for first quarter. The Southern market has been advancing steadily and late in September reached $14.50, Birmingham, with predictions freely made that $16 would be reached by early in the new year

Unfinished Steel.

Most of the mills have disappeared as sellers of billets, having their steel output fully taken up by their own finishing departments. All lines of unfinished steel have advanced from $1 to $2 since last report, and are hard to get at the advanced prices. We quote, f.o.b. mill, Pittsburgh district: Bessemer billets, $25.50 to $26; open-hearth billets, $26 to $26.50; sheet bars, $26.50 to $27; Bessemer rods, $31.50; open-hearth rods, $32. The Carnegie Steel Company has started its sheet bar mill at Columbus, Ohio, its smallest Bessemer operation, and now has practically all its Bessemer and open-hearth capacity in operation.

Finished Materials.

Bars, plates and shapes, as already noted, have advanced since last report. While mills are sold up for from 4 to 10 weeks ahead on nearly all classes of material, the tendency is to ask higher prices the farther forward the delivery. In some lines business will not be done for next year, while in general engagements will not be made beyond the first quarter. An exception, of course, is rails. Total bookings for 1910 delivery now exceed 300,000 tons. The market is quotable as follows, f.o.b. Pittsburgh:

Steel bars, $1.40, base.
Iron bars, $1.50 to $1.55, base.
Plates, $1.50.
Shapes, $1.50.
Standard rails, $28 for Bessemer and $30 for open-hearth, f.o.b. mill; light rails, 25 lb. to 45 lb., $28.

Sheets, 28 gage, black, $2.20; galvanized, $3.25; corrugated roofing, $1.55 per square for painted and $2.80 for galvanized.

Merchant steel pipe, ¾ in. to 6 in. inclusive, extreme price 8t and 5 off list; wrought-iron pipe, 75 and 5 off list.

Plain wire, $1.60; wire nails, $1.80, base; painted barb wire $1.80; galvanized barb wire, $2.10.

A Court Decision on the Fume Question.

In the injunction proceedings of Phoebe Gore and others against the Clarksburg Zinc Company (which treats "salammoniac skimmings"), an opinion has been rendered by Judge Charles W. Lynch, in which he declines to abate the company's plant as a public nuisance. From the full opinion of Judge Lynch, as printed in the *Daily Telegram* of Clarksburg, W. Va., we quote the following:

It is pointed out that there is an immense mass of directly contradictory testimony. But "one fact, at least, is proven, in effect practically conceded, viz., that at times, either prior to the institution of this suit, or afterward and before the injunction was awarded, the resultant effect from the plant's operation was injurious to both animal and vegetable life, and especially the latter, for within a reasonably brief period trees and plants within the immediate reach of the noxious gases or vapors, and apparently healthful, were about that time denuded to some extent of their foliage without apparent cause other than reasonably chargeable to the operation of the factory.

"The defendants seek to excuse this result by evidence to the effect that the part of the plant generally known as the roaster was then but recently installed and had not been properly reduced to a good working basis. In other words, that it was in the experimental stage."

The defendants now claim that by changing the roasting plant the fumes have been entirely changed and are no longer detrimental to health. This the complainants deny, but their testimony is in the main from the plaintiffs themselves, while the defendant company produced expert witnesses. "The court must of necessity attach more weight and credit to the testimony of expert witnesses, that is, witnesses who are specially informed and whose special study has been to know accurately the nature and character of the gases and vapors produced and discharged in the operation of the factory, than to the testimony of those who do not pretend to know the character or nature of the gases or vapors so produced."

The final conclusion of Judge Lynch is as follows:

"The defendants are engaged in a useful and lawful business It is not a nuisance per se. That, however, does not confer upon them the right to unnecessarily harass the plaintiffs in the enjoyment of their homes. Both must be protected so long as they can reasonably exist together. As Judge Holt has said, courts must 'apply the common-sense doctrine that the parties must give and take, live and let live.'

"There must, therefore, be a decree refusing to abate the Clarksburg Zinc Works as a nuisance, but at the same time restraining and enjoining the defendants and each of them from the use of any material in the distilling or roasting furnaces the reduction of which will produce into the air any gases or vapor causing physical injury or damage to the person or property of the plaintiffs."

Electric Iron and Steel Industry in Canada, and in Sweden and Norway.

We are glad to hear from Mr. Louis Simpson that negotiations for an electric iron-ore reduction and steel plant in Canada are well advanced. The first plant is to have a capacity of 5000 hp.

From a pleasant interview which we had with Mr. Assar Grönwall (one of the three inventors of the electric iron reduction furnace recently investigated and officially reported on

by Dr. E. Haanel, Director of Mines, Ottawa, Canada), we learn that considerable progress has recently been made in Sweden and Norway in this field. Mr. Grönwall was only a week in the country and was called back to Europe to meet a delegation from the largest iron and steel works in Russia.

From Mr. Gronwall we learn that the iron-ore reduction furnace described and illustrated in Dr. Haanel's paper in our June issue has been working continuously for three months, until July 3, when the general strike in Sweden caused a stoppage of operation. One point which Mr. Grönwall emphasizes is that they have had no trouble whatever with their electrodes. In their three-phase furnace two of their electrodes were sometimes moved for demonstration purposes, but one electrode of the three was purposely not moved and remained in satisfactory condition for six weeks. It was then adjusted and could stand another six weeks.

The electrodes are immersed in the charge, but do not dip into the molten iron at the bottom of the furnace. In tapping the furnace the ammeter does not move, which proves that practically no current is passing through the molten iron at the bottom.

One point strongly emphasized by Mr. Grönwall is that the combination of an electric reduction furnace with electric steel furnaces is important because it is easy to make in the former a pig iron of low carbon content, say, 1° C. If the molten pig iron is transferred directly to the electric refining furnace, the time necessary for getting the desired quality of steel is much less than with present electric steel refining practice. He states that this practical elimination of the carbon in the reduction furnace is very important, since the comaparatively long time required in present electric steel refining practice for reducing the carbon content is completely saved. From the three months' running of their reduction furnace they conclude that there can be no doubt of its working efficiently on a large commercial scale.

* * *

In this connection it is interesting to note the official report of Dr. Eugene Haanel to the Canadian Government on his visit to Sweden, where he investigated the electric reduction furnace above mentioned at the Aktiebolaget Electrometall, at Donnarfvet, Sweden. The report proper gives details of this investigation by Dr. Haanel. Since the chief results were already given by Dr. Haanel in his American Electrochemical Society paper at Niagara Falls, published in our June issue, we will only quote the official final statements in the report:

"The trial run was intended to elucidate the following points:

"(1) Whether undisturbed and uniform working without troublesome regulation of the electrodes could be obtained.

"(2) Whether great variations in the consumption of energy would occur.

"(3) Whether the free spaces within the melting chamber would be maintained with a shaft considerably higher than in the furnaces of earlier design and construction.

"(4) Whether the contraction of the shaft would prevent the charge from sinking uniformly, or cause hanging.

"(5) The durability of the arched roof, and the possibility of cooling it by means of the circulating gas.

"The following is a summarized statement of practical deductions drawn from observations made during the trial run, having regard to the objective points specified above:

"(a) It was observed that the furnace operated uniformly and without trouble of any kind, and that the electrodes required absolutely no regulation, in one case, for five consecutive days. In any case, the only regulation required is that corresponding to the consumption of the electrodes, and is necessary only once a day, and sometimes not for much longer periods. On account of this, expensive regulations can be dispensed with.

"(b) During the short trial, even though the furnace did not approach its normal working condition until toward the end, it was observed that the consumption of energy was remarkably uniform. This can readily be seen from an inspection of the readings of the different instruments.

"(c) Free spaces were maintained between the linings of the roof and the walls, and the electrodes and the charge at the openings where the electrodes enter the melting chamber.

"(d) It was found that the charge did not jam in the lower contracted neck of the shaft, as had been feared, but moved with regularity into the melting chamber.

"(e) Although the gases generated by the reduction of the ore were not circulated through the cooling tuyeres until near the end of the trial run, it was demonstrated that the lining of the roof of the melting chamber was effectively cooled by this means."

Since the sectional drawing of the furnace was published in our June issue, we reproduce herewith only an outside view of this electric shaft furnace (Fig. 1).

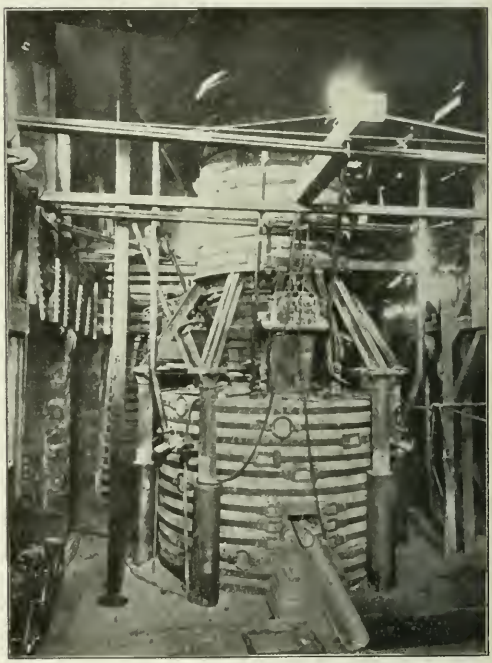

FIG. 1.—ELECTRIC REDUCTION FURNACE FOR IRON ORE.

Dr. Haanel's report then contains a comparison, by Professor von Odelstierna, of Stockholm, of the cost of production of pig iron in a charcoal blast furnace and an electric shaft furnace based on conditions in Sweden. This comparison is as follows:

"If we take as a basis for our comparative study an ordinary charcoal blast furnace and the electric shaft furnace erected at Domnarfvet, and suppose the iron ore used in these furnaces to contain 60 per cent metallic iron, and the charcoal 83 per cent carbon, then it should be possible to make a reliable comparison. It should be pointed out, however, that in this comparison no account is taken of the fact that the gases produced in the electric shaft furnace contain a higher percentage of CO —probably 60 per cent more—than the ordinary blast-furnace gases.

"In regard to the labor charges and general expenses, I make the supposition that these charges are the same for both the electric shaft furnace and the charcoal blast furnace, if the contrasted furnaces are of such capacity as to produce the

same quantity of pig iron per year. A charcoal blast furnace of medium capacity produces in Sweden about 8000 to 10,000 short tons of pig iron per annum—a quantity which, I believe, can also be produced in a properly constructed electric shaft furnace of the type of Atkiebolaget Electrometall.

"Cost of pig iron per short ton, in dollars:

Charcoal Blast Furnace.		Electric Shaft Furnace.	
Charcoal, 0.95 ton, at $8 per ton	$7.60	0.27 ton charcoal	$2.16
Labor	1.00	0.3 E. H. P. year at $12	3.60
Repairs and general expenses	1.50	Labor	1.00
		Electrodes, 10 lbs., at 3c per lb.	.30
		Repairs and general expenses.	1.50
Total	$10.10	Total	$8.56

"In this calculation the price of ore and limestone, and the royalty are not given, as the former varies with the locality and the character of the ore, and the latter has not yet been determined.

"From this calculation it is apparent that in Sweden, under the above-mentioned circumstances, a saving of $1.55 should be effected in the production of pig iron by the electrothermic process."

It may be interesting to note in this connection that according to reliable reports which have reached us, quite satisfactory progress is also being made with electric iron-ore reduction in the Noble plant in California. (See our June issue.)

Electric Steel Furnace

In the second part of Dr. Haanel's report an interesting description is given of the electric steel furnace of Assar Grönwall, Axel Lindblad and Otto Stalhane, the three inventors of the iron-ore reduction furnace referred to above.

"Either a two-phase or three-phase current can be used with this furnace, which has but two adjustable electrodes; the bottom of the hearth—composed of magnesite, intermixed with a small amount of graphite—forming the third.

"By the special distribution of the electrodes the bath is caused to rotate in a vertical plane, thus continually bringing new material in contact with the slag for purification. The time required for refining is by this means considerably shortened.

"If the current to be supplied is two-phase, an ordinary two-phase transformer can be used with the furnace; but if the supply is three-phase, two single-phase transformers with Scott's connection can be used."

The two-phase current is supplied to the furnace in such a manner "that the terminals of one pole of the two phases are each electrically connected with one of the two adjustable electrodes of the furnace, while the terminals of the other poles of the two phases are electrically connected with the lining of the furnace." The currents from the two electrodes thus pass in form of two arcs into the bath; the current in the bath is $\sqrt{2}$ times the current in each phase. The current leaves the furnace through the bottom lining.

A vertical section of the furnace and a horizontal section (at the top) are shown in Fig. 2.

"The furnace* is built on iron plates 10, which also serve as conductors for the resultant current of the phases; for this purpose they are connected with the conductors 14. The walls are constructed in the usual manner. When soft iron or steel is to be produced, the lining is made of magnesite, dolomite or quartz. Since these substances are conductors of the second class, and consequently must be at rather a high temperature in order to conduct electricity well, a layer 11 of graphite, for example, would be rammed in on the plates 10. This material, when cold, is an excellent conductor of electricity and serves the purpose of conducting the current until the lining attains the proper temperature to become itself a conductor. Where the lining is composed of magnesite or dolomite, with tar, pitch or the like, as an adhesive, it is usually a sufficiently good conductor, on account of the carbon introduced in this manner, even when in a cold condition. Under these conditions the conducting layer 11 can then, if desired, be omitted. The two electrodes 12 are connected to the free ends of the phases. These electrodes penetrate into the cupula of the furnace and are adjustable. For the purpose of protecting the brickwork of the cupola the electrodes pass through water-

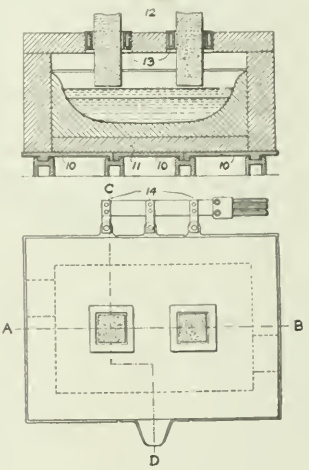

FIG. 2.—ELECTRIC STEEL FURNACE.

cooled stuffing boxes 13. The electrodes are so adjusted that there is formed between them and the bath or layer of slag floating thereon an arc of suitable length.

"With this furnace all processes occurring in the production of iron and steel, such as puddling, desulphurization, dephosphorization, etc., can be carried out."

* * *

In the third and fourth parts of Dr. Haanel's report some important accessories of electric iron and steel plants are discussed.

Part III deals with factories for making carbon electrodes, and contains essentially a description, by Mr Jens Orten-Boving, of London, of a factory producing yearly 3000 tons of large size carbon electrodes. This description is based on facts and operating results obtained from two large factories, constructed on similar lines. The first is that of Messrs. Hoganas Billesholm, Limited, of Sweden, who have a carbon factory of 2000 tons yearly output, making electrodes for carbide furnaces, steel smelting furnaces and aluminium works. The second plant is that of the British Aluminium Company, Limited, who have a factory at Kinloch Leven, Scotland, producing yearly 6000 tons of electrodes for their own aluminium works.

A discussion is given of the raw materials used, the general arrangement of works, the coarse crushing plant, the fine crushing plant, the heating, mixing of coal and tar, presses and pumping plant, and Menheim's gas kiln. Finally, an estimate is given of the cost and operating expenses.

*The above description is taken by Dr. Haanel from the Swedish patent specification of the inventors. It will be seen that, aside from the polyphase connections, the furnace resembles the Girod type rather than the Heroult type, since it has an electric bottom connection. But it differs from the Girod type in the nature of the furnace bottom. As we understand from our conversation with Mr. Gronwall, the furnace bottom as they now use it, is essentially a "conductor of the second class." That means, when cold, it does not conduct. Just like the "pole plates" in the Roechling-Rodenhauser furnace, the bottom in the Grönwall-Lindblad-Stalhane furnace must be preheated in order to become a conductor. In the Roechling-Rodenhauser furnace this is done by the charge itself heated by induction. This permits a quick starting of the furnace, but it makes necessary a combination of an induction furnace with a pole-plate furnace. The Gronwall-Lindblad-Stalhane furnace avoids any complications in construction, but it requires quite some time for starting. This is no disadvantage, as it is intended for continuous operation only. When the furnace is to be started, coke is filled in, and by burning the coke the furnace bottom is brought to the required temperature to become a conductor. This may take a day, but when the furnace is then started, it can be used continuously.—Editor.

In the fourth chapter a review is given of modern methods of manufacturing charcoal for electric iron-ore reduction furnaces.

This full and well illustrated "Report on the Investigation of an Electric Shaft Furnace" at Domnarfvet, Sweden, may be obtained on application to Dr. Eugene Haanel, Director of Mines, Department of Mines of Canada, Ottawa, Canada.

Together with his well-known two former reports, this third report of Dr. Haanel forms a trilogy which may well be characterized by the statement made about the first report by an English technical contemporary: "It stands a monument of legitimate Government activity, directed with intelligence and achieving its goal."

New York Meeting of American Electrochemical Society.

The autumn meeting of the American Electrochemical Society will be held in New York City on Oct. 28, 29 and 30 (Thursday to Saturday of the last week in October).

While the program has not yet been definitely arranged, it is probable that sessions for the reading and discussion of papers will be held on Thursday afternoon and Saturday morning; perhaps also on Saturday afternoon.

The whole of Friday will probably be devoted to an excursion to the numerous and exceedingly interesting chemical and metallurgical plants in Bayonne City, the plants on Constable Hook to be visited in the morning, those on the Newark Bay side in the afternoon. On the evening of Friday a banquet will be held in New York City.

The local committees are making strenuous efforts for the entertainment of visitors, and especially of the ladies. The program of papers to be presented at the professional sessions is stated to be again very interesting. The hotel headquarters will be at the Hotel Cumberland, Broadway and Fifty-fourth Street.

American Institute of Chemical Engineers.

The annual meeting of the American Institute of Chemical Engineers will be held in Philadelphia from Dec. 8 to 10. Excursions to a number of centers of interesting chemical industries in the vicinity is being arranged for. The program of papers to be presented will be published later.

Coke, Gas, Tar, and Ammonia.

The manufacture of coke by processes that will permit the saving of the by-products gas, tar, and ammonia, and thus reduce to some extent the enormous wastefulness of the beehive ovens, is discussed by E. W. Parker in an advance chapter of "mineral resources of the United States, calendar year 1908," just issued by the United States Geological Survey.

During the last 15 years considerable progress has been made in the manufacture of coke in retort ovens, with the recovery of the by-products, but the future development of this branch of the industry depends largely on the ability of the operators to dispose of the by-products at remunerative prices. They come directly into competition with the products of gas-house retorts, and the situation thus created has developed a demand for information in respect to the total quantities produced and the values.

The quantity of coke produced at gas works and by-product coke ovens in 1908 was 6,253,125 short tons, a marked decrease from the figures of 1907 (8,093,144 tons), the business depression causing a heavy falling off in the demand. The value dropped from $30,332,644 to $21,507,045, a reduction of nearly $9,000,000.

Gas showed a slight increase in value, the quantity sold being 53,561,811,000 cu. ft., valued at $37,227,901, in 1908, as compared with 54,819,685,000 cu. ft., valued at $36,462,304, in 1907.

Tar and ammonia decreased slightly, the figures being 101,261,829 gal. of tar, valued at $2,537,118, in 1908, against 103,577,760 gal., valued at $2,651,527, in 1907; 30,615,835 lb. of ammonia, valued at $2,065,169, in 1908, against 37,560,858 lb., valued at $2,601,057, in 1907; and 44,093,437 lb. of ammonium sulphate, valued at $1,322,807, in 1908, against 48,882,237 lb., valued at $1,525,472, in 1907.

The coal carbonized in this production amounted to 9,252,978 short tons, against 11,490,661 short tons in 1907. The increasing popularity of gas for cooking and heating purposes is shown by the fact that the proportion of the total production used for these purposes in 1908 was double that of 1902.

Mr. Parker's report, which is issued in pamphlet form, may be had free of charge from the director, United States Geological Survey, Washington, D. C.

Competition for Light Metals.

The "Ila" (Internationale Luftschiffahrt Ausstellung or International Aeronautic Exposition) now being held in Frankfort-on-the-Main has arranged a prize competition for light metals. The arrangements have been made by the Scientific Commission of the Exposition, the president of which is Prof. Dr. Wachsmuth. We understand that the number of those who have entered the competition is quite considerable and that great interest is being taken in the results to be expected from the competition. The final date by which materials had to be submitted for tests was Sept. 15. The following conditions will be considered in the competition: The metal should have a very low specific gravity, great strength, great resistivity, and high elasticity. It should be capable of being easily machined; to prove this finished and half finished parts of motors and balloons should be submitted. The metal should also have a great resistivity against air and alkalies and acids. A gold, silver and bronze medal will be given to the firms which get the highest number of points in the competition. We hope to report on the results later on.

CORRESPONDENCE.

Strontium.

To the Editor of Electrochemical and Metallurgical Industry.

Sir:—A friend of mine has upon his property a limestone deposit containing a considerable quantity of strontium. Analyses of samples are as follows:

	No. 1 Sample.	No. 2 Sample.	No. 3 Sample.
SiO_2	7.23	7.20	10.20
FeO	0.50	0.50	0.99
Fe_2O_3	0.90	0.90	1.20
Al_2O_3	0.55	0.63	2.80
K_2O	0.49	0.45	0.58
P	trace	trace	trace
MgO	1.22	2.12	0.97
SrO	5.36	4.12	13.77
CaO	44.60	44.04	34.10
CO_2	39.20	39.29	34.54
H_2O	0.53	0.74	1.10
	100.58	99.99	100.25

Can any of your readers say whether this percentage of strontium is of economic value? The limestone appears to be a good one for use in the manufacture of Portland cement. Will the strontium be beneficial in this connection?

I have looked through the Transactions of various societies without finding any reference to this point, and shall be glad to learn where any information may be obtained in relation thereto.

Wallaroo, So. Australia. H. Lipson Hancock,
General Manager, Wallaroo & Montana Mining & Smelting Company, Ltd.

The Metallography of Iron Clarified.

By Henry M. Howe.

Mr. A. Baykoff's late results[1] have opened the way to an important change in our theory of the nature of the familiar martensite needles, and through this change to a welcome simplification of the metallography of iron.

The conditions were these: The evolution of heat, both when carbonless iron cools down into region 5a of the Roberts-Austen diagram, Fig. 1, and also when it cools thence into region 5b, had indicated the existence of beta iron, something different from the gamma iron known to exist in region 4 and from the alpha iron known to exist in region 5b. The fact that this beta iron seemed to be bulkier and also more brittle and

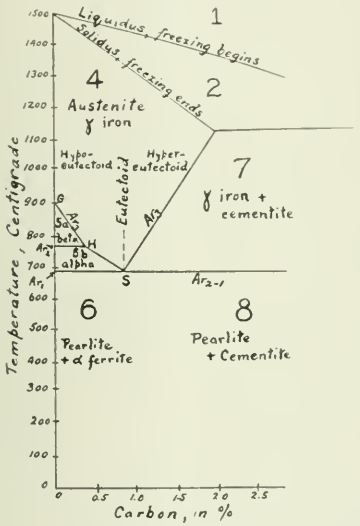

FIG. 1.—THE ROBERTS-AUSTEN OR CARBON-IRON DIAGRAM.

much harder than either gamma or alpha iron had showed that it was not a mechanical mixture of these two phases, but a distinct entity. A variety of evidence had tended to show that these martensite needles, Fig. 2, represented this beta state. But Mr. Osmond, to whom more than to anyone else our present theories are due, in his classical work on the crystallography of iron[2] had reported results which seemed to prove positively that these needles were not of beta, but of gamma iron. Mr. Baykoff's present results, while they do not in themselves prove that the needles are beta instead of gamma, yet overthrow Mr. Osmond's apparent proof that they are beta, by showing that his evidence is vitiated by his omitting a simple precaution, the need of which might easily pass unnoticed. It is not clear that Mr. Baykoff was aware of these results of Mr. Osmond.

In view of the inconclusiveness of the evidence of both these observers as to the nature of the needles, we are thrown back on the general attendant conditions, which certainly do not oppose, and to me, at least, seem to favor strongly, the theory that the needle structure represents beta iron. After explaining this, I will suggest a crucial experiment.

In order to understand the matter we should go back a little.

When iron is heated up into region 4 of the Roberts-Austen diagram, Fig. 1, it passes spontaneously into the non-magnetic, gamma, polyhedral condition, called austenite, of which the typical structure is shown in Fig. 3. If it is hypo-eutectoid, i.e., if it has less than 0.90 per cent of carbon, then as, in cooling, it passes successively into (1) region 5a, (2) region 5b, and (3) region 6; according to our present theory, it passes successively through the stages of (1) gamma iron mechanically mixed with a progressively increasing quantity of beta ferrite, (2) gamma iron mechanically mixed with progressively increasing quantities of alpha ferrite (because the beta ferrite changes to alpha on cooling past Ar_2), and (3) alpha ferrite mixed with pearlite, which itself is in the alpha state. If it is hyper-eutectoid, i.e., if it contains more than 0.90 per cent of carbon, in cooling successively into (1) region 7 and (2) region 8, it passes into the stages of (1) gamma iron mixed with cementite at the line Ar 3 (ST) and (2) pearlite mixed with cementite at the line Ar 2-1 (SP'), in this last step either passing through or skipping over the beta state.

FIG. 2.—MARTENSITE NEEDLE STRUCTURE.

The point to remember is that the beta state is intermediate between the gamma, or high temperature, and the alpha, or pearlite or low-temperature state. But though this change from gamma through beta into alpha iron thus tends to occur in cooling through the "critical range" (regions 5a, 5b, and 7), it can be held in check like a bent spring by the action of what I call the "obstructive elements," carbon, manganese, and nickel. It is obstructed so strongly by manganese and nickel that it does not occur at all in steel containing 12 per cent of the former or 25 per cent of the latter metal, even if the cooling is slow. Such steel has the characteristic polyhedra of the gamma state.

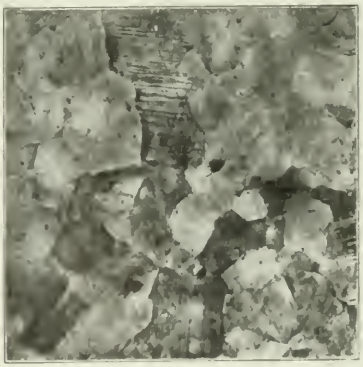

FIG. 3.—POLYHEDRAL GAMMA IRON, OR AUSTENITE STRUCTURE, IN MANGANESE STEEL.

The obstructive action of carbon is much feebler. Indeed,

[1] *Revue de Métallurgie*, VI, p. 829, July, 1909.

[2] *Annales des Mines*, XVII, p. 110, and XVIII, p. 113. See especially p. 150.

carbon is not an arrester, but only a retarder of this change, so that, in order that its obstructiveness shall be effective, it has to be reinforced by cooling the metal rapidly from region 4, so as to deny the time which the change thus retarded needs in order to complete itself. In other words, carbon and rapid cooling have to co-operate in order to obstruct effectively the change from gamma through beta into alpha iron, and neither by itself has any important obstructive effect. Thus steel wholly without carbon, no matter how rapidly it is cooled from region 4, passes eventually into the alpha state, though this change may not complete itself until some time after the rapid cooling has ended. So, too, no matter how much carbon steel may contain, it passes wholly into the alpha state in slow cooling. But when the effect of carbon is reinforced by rapid cooling, the two many jointly retain apparently some 70 per cent[3] of the metal in the gamma state, and the remaining 30 per cent partly in the beta state. This 30 per cent has the martensite

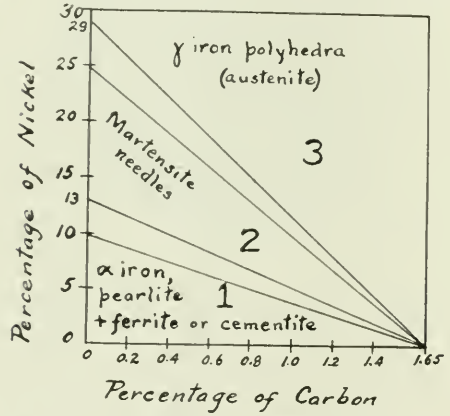

Fig. 4.—Approximate Relation between the Composition and Structure of Iron-Nickel-Carbon Alloys (Nickel Steels). Guillet, "Revue de Metallurgie," Vol. II, p. 351, 1905.

Note to Fig. 4. This diagram is not be taken too literally. For instance, it implies that, with 1.65 per cent of carbon and any minutest quantity of nickel, the steel consists wholly of gamma iron (austenite), whereas in fact, even after the most rapid cooling thus far used, only about 70 per cent of the mass shows the structure of gamma iron, and of that which shows this structure no inconsiderable part may actually be alpha. Again, the diagram takes no account of the rate of cooling, but suggests that the conditions of cooling which apply to one part apply also to all the rest. But, in fact, steel, such as we have just been considering, will not contain any gamma iron at all unless cooled rapidly, whereas steel with 29 per cent of nickel and no carbon does not need rapid cooling to keep its iron in the gamma state. Nevertheless, the diagram is of value as cleverly reducing a great mass of facts to a very simple expression.

needles as to which we are asking. In order to cause so great a degree of obstruction there must be somewhere about 1.60 per cent of carbon present. If there is no more than 1 per cent, then, no matter how rapid the cooling, little, if any, gamma iron can be detected in the cold metal, which apparently consists of a mixture of beta and alpha iron, with the high magnetic retentivity which such a mixture ought to have. Such steel consists wholly of martensite needles. Here we have our first indication that these needles represent the beta state, but the existence of this beta state was first indicated by the evolutions of heat in cooling detected by Mr. Osmond.

(1) Again, manganese can reinforce the joint effect of carbon and sudden cooling. Thus, if, as in Dr. Maurer's steel,[4] this metal contains 2 per cent of carbon and also 2 per cent of manganese, the obstruction is so great that an extremely rapid cooling, such as occurs when thin objects are quenched in ice water, seems to prevent the change from gamma iron to martensite completely, and to retain the metal wholly in the polyhedral gamma state.

(2) Again, if the gamma state has been preserved by the joint action of carbon and sudden cooling, and if the metal is permitted to escape from this state, i.e., if the change from the gamma toward the alpha state is allowed to begin by subcooling the quenched steel in liquid air (which seems to act by releasing the pressure under which the suddenly cooled article is), then the gamma iron changes not into alpha iron, but into the familiar martensite needles, as was first shown by Mr. Osmond.

(3) This same principle is illustrated by Guillet's diagram of nickel steel, Fig. 4, which is martensite if the sum of the carbon plus the nickel is that which corresponds to his region 2, and has the gamma iron polyhedra if this sum is great enough to correspond to region 3 of his diagram.

The thing to note here is that, when the obstruction is very great, the cold metal retains the characteristic gamma iron polyhedra. When the obstruction is only moderate, the cold metal has the equally characteristic martensite needles, which thus seem to represent a stage between alpha and gamma, presumably beta.

We have now seen that the martensite needles seem to represent a stage intermediate betwen alpha and gamma iron. This, as far as it goes, tends to identify them with beta iron. But I will now go farther and try to show that they are identified with (1) greater specific volume, greater brittleness, and (2) to (9) much greater hardness than those of either alpha or gamma iron, a fact which argues strongly that they are not a mechanical mixture of alpha and gamma, and hence that they really represent the intermediate beta stage which Mr. Osmond's thermal studies had shown to exist. I will then show how Mr. Osmond's results seem to contradict this conclusion, and finally try to explain them away.

(1) *Specific Volume.*—Benedicks[5] has brought together data which show that the specific volume of martensite is greater than that of either gamma iron or alpha iron (austentite or pearlite), so that the changes of volume may be indicated graphically by a sketch like Fig. 5. Maurer, too, has since shown that the specific volume of martensite is greater than that of austenite,[6] thus strengthening Benedicks' conclusion where it most needed strengthening, for the well-known greater volume of hardened than of annealed steel tended to show that martensite is bulkier than alpha iron.

Fig. 5.—Qualitative Relation between the Specific Volume of Austenite, Martensite and Pearlite.

(2) *Hardness.*—Of the martensite needles and the gamma iron polyhedra found in very rapidly cooled high-carbon steel, the needles are harder than the polyhedra, as Osmond showed years ago.

(3) The needle-bearing nickel steels of Guillet's intermediate region 2 are, in general, harder and more brittle than the polyhedral gamma irons of his region 3.[7]

(4) Manganese steel containing an intermediate quantity of the obstructive elements, manganese and carbon jointly, is very much harder and more brittle than the common, polyhedral, gamma manganese steel of commerce, which contains much more of these elements.

(5) If the quantity of the obstructive elements is intermediate, and barely enough to retain the metal in the gamma state, mechanical deformation shifts it over from the regular polyhedral gamma state into the needle martensite state, and also

[3] *Op. cit.*, Journal Iron and Steel Inst., LXXVII, pp. 224-5, 1908, II.

[4] *Revue de Métallurgie*, V, p. 720, Oct., 1908.

[5] Guillet's observation that low carbon niccoliferous martensite, though hard, is only moderately brittle (la fragilité—n'est pas très grande), does not break the force of this argument. That under many or even under a few conditions martensite excels both austenite and alpha iron would in itself be enough to indicate that it is not a mechanical mixture of them. *Rev. de Métallurgie*, II, p. 351, 1905.

[6] *Journal op. cit.* XXVIII, p. 12.

[7] *Revue de Metallurgie* V, p. 742. Phets 19, 1908

makes it much harder and more brittle. This seems to be true whether we have to do with manganese alone or nickel alone, or with any mixture of them with carbon.

This change may be explained readily. The martensite state is bulkier than the gamma state. Distortion in the cold causes local pressure in one part and local tension in another, one probably alternating with the other as the deformation proceeds. The existence of tension always favors the passage into the bulkier of two possible states, and hence in this case opposes the obstructive elements, so that their obstruction thus weakened is no longer able to prevent the gamma iron from following its natural course and shifting over into the bulkier beta state. It is true that such tension may be immediately followed by pressure. But *vestigia nulla retrorsum*. This pressure is unable to reverse the change and force the beta iron back into the gamma state.

Maurer's 2 per cent manganese and 2 per cent carbon steel was so unstable that deformation readily shifted it into the martensite-needle state.[9]

This explanation which I give is suggested by Benedicks' brilliant discovery that release of pressure shifts gamma iron into martensite.[9]

(6) Again, if, as in Dr. Maurer's steel,[10] the effect of the obstructive elements is insufficient to retain the metal in the gamma state unless reinforced by the rigidity of the cold state, then if the metal is slightly reheated so as to relax this rigidity it becomes very much harder, though I must admit that in this case the formation of martensite needles has not been detected.

(7) It is in the same way that I would provisionally explain the heat treatment of high-speed steel. The first quenching from an extremely high temperature preserves the gamma austenite state. The second heating starts the change from the gamma toward the alpha state, but carries it only far enough to set up the intermediate much harder martensitic beta state, and it is in this state that the tool does its wonderful cutting, the obstructive action of the tungsten, etc., retarding the transition through the beta state even at a low red heat, so that the tool will cut at this temperature for a considerable time. But in spite of this retarding of the change, it is accomplished at last, and after the metal has staid a while at this red heat so little of it remains in the hard beta state that it no longer cuts efficiently This, at least, is an explanation, and one which is in harmony with a large body of well-known facts. Whether it is the true one I cannot now pretend to say.

(8) The martensite needles formed when gamma iron, preserved by sudden cooling, is sub-cooled in liquid air, are much harder than the austenite whence they have sprung.[11]

(9) Finally, austenitiferous high-carbon steel quenched from a very high temperature, when tempered by slight reheating, instead of losing its hardness as martensitic hardened steels so familiarly do, becomes materially harder, according to the report of Mr. F. Robin,[12] and simultaneously loses its austenitic structure, further suggesting that the change from gamma toward alpha passes through the beta state harder than either, and hence not a mechanical mixture of the two.

And now for our puzzle. Two facts were prominently before us: First, that divergent as are the conditions under which we are able to trap iron in the needle state, those conditions always have one thing in common: that they represent a transition between the alpha and the gamma states.

Second, these needles are associated with hardness, brittleness, and specific volume greater than those of either the alpha or the gamma state, and hence not with a mechanical mixture of alpha and gamma, but with a different entity, almost necessarily beta iron by definition.

These facts were true whether we trapped the needles in passing from alpha toward gamma or in the opposite direction, whether by rapid cooling, by any combination of the obstructive elements, or by both means jointly; whether by cooling at an intermediate rate, by gentle reheating, by mechanical distortion, or by sub-cooling in liquid air.

The argument from these facts may be summed up thus: The fact that an excess of hardness, brittleness, and specific volume over those of both alpha and gamma, an excess which in itself argues the presence of the beta state, is accompanied under such widely divergent conditions by the needle state indicates very strongly that the needle state represents the presence of beta iron. Nevertheless, Mr. Osmond[13] seemed to prove absolutely that it did not, but, on the contrary, that it was nothing but the "crystallitic" or imperfectly developed stage of gamma iron, through which it might naturally pass before forming its true crystalline polyhedra. This he did by showing that etching steel in region 4, where the iron should be wholly gamma, with either calcium chloride or hydrochloric acid, developed these needles along with the true gamma polyhedra Indeed, in one case though a shorter etching in calcium chloride yielded polyhedra, a succeeding longer one applied to the same specimen yielded the martensite needles This might suggest that there was no great difference in stability between the polyhedra and the needles, or even that the needles were the state to which the polyhedra tended. The polyhedra which Mr Samter, the inventor of the calcium-chloride method, found were often marked with needles

The natural escape from this trouble seemed completely blocked. One's first idea would naturally be that Mr Osmond was mistaken in his interpretation of the facts, and that the needles represented either beta iron or at least the contamination of gamma by beta iron. The needles were apparently of the isometric system, t which both gamma and beta iron belong.[14] There was o this no reason, then, why these isometric needles should not represent gamma iron thus contaminated.

[9]*Revue de Métallurgie*, V, p. 744. Photos 27 and 28, Oct., 1908.

[10]*Journal, Iron and Steel Institute*, 1908, II, p. 241.

Among other ways in which he proved this was by showing that, when austenite which had been preserved by sudden cooling is further sub-cooled in liquid air and is then very suddenly reheated, as it must be when it is taken suddenly out of the liquid air and exposed to the relatively hot air at the room temperature, the sudden expansion which the outside of the specimen then undergoes throws the interior into such great tension as to permit its iron, locked in the gamma state by the sudden cooling and the pressure which accompanied the early part of that cooling, to change to the martensite state. The interior of the specimen would, at the end of the original rapid cooling, be in strong tension and the outside in strong compression, because in the latter part of that cooling the inside is cooling much more rapidly than the then cool and rigid outside. The sudden expansion of the outside on emerging from the liquid air then throws additional tension on the interior, which was already under great tension.

Now this explanation is extremely welcome, because the phenomenon was not, in my opinion, reasonably explained before.

In cooling from the gamma into the alpha state two opposing forces are at work. The gamma iron tends to change into beta and thence into alpha, but this change is opposed by molecular inertia or viscosity. The tendency to undergo the change increases with what we may call the temperature lever arm, i. e., the temperature-interval between that at which the change is theoretically due and the existing temperature As the temperature is progressively lowered, it reaches a point at which the temperature lever-arm becomes long enough, and the tendency to change therefore strong enough, to overcome molecular viscosity, and the change occurs. As the temperature sinks still farther, the tendency to change increases in strength at first more rapidly than the viscosity does, so that the change takes place with greater and greater rapidity. But there is a limit to this, and with further fall of temperature the reaction velocity reaches a maximum, again falls off, and finally the reaction is arrested, when the temperature has sunk so low that the viscosity due to the cold completely arrests the change. This is what occurs in the hardening of steel by sudden cooling in cold water.

Now the change from austenite into martensite by sub-cooling in liquid air seemed to indicate that, though in the race from Ar I to 20° the viscosity had overhauled and finally distanced the effect of the temperature lever-arm, in continuing that race from 20° to the liquid air temperature the conquered had somehow become the conqueror, and the reaction, arrested at 20°, now occurred. Why should this victory be thus reversed? This was certainly hard to understand, and I had long looked for some other explanation.

The welcome theory that the recurrence of the change is due to the increase of tension in heating up from the liquid air temperature can easily be tested. Quench a piece of 1.60 per cent carbon steel in ice water so as to preserve as much gamma iron as possible. Cut it into two like pieces; immerse them both in liquid air in a Dewar's flask, withdraw one and let it rise rapidly to atmospheric temperature, e. g., by moving it quickly through alcohol. Leave the other till the liquid air has evaporated, when immediately cork the flask up and allow it to rise at its natural very slow rate to atmospheric temperature. If the theory is right, the change into martensite should be less complete in this second piece than in the first, and, further, the change should be confined to the interior of the piece, which alone is thrown into tension in the heating up.

[11]*Revue de Métallurgie*, V, p. 723, Fig. 12, Oct. 1908.

[12]Maurer, id. m. V, p. [illegible] Oct., 1908

[12]Idem, V, pp. 9[illegible] to 9[illegible]3, Dec., 1908. Three curves in his Figs. 6 and 7 show the peculiarity but the increase in hardness on subsequent cooling in the curve shown in Fig. 7 is so surprising as to call for verification

[13]*Annales des Mines*, XVIII, p. 145, 1[illegible]

[14]It is true that Le Chatelier and Ziegler get suggestions that gamma iron is hexagonal but Osmond's evidence to the effect that it is cubic seems overwhelming [illegible] Soc. D'Encouragement, X, pp. 375-6, Sept 1902

[illegible] mond, why they should not represent beta iron itself. But this escape, as I have said, seemed completely blocked by the fact that Messrs. Osmond and Saniter got these martensite needles even after long exposures to temperatures at which the change to gamma iron seems to be extremely rapid, to temperatures not only far above Ac 3, but even rising to 1000 deg. C. At these temperatures the metal ought to pass beyond the beta into the gamma state rapidly, for if anything is familiar it is that when steel is heated above the critical range, i. e., into region 4, it acquires the hardening power, i. e., it travels from the alpha toward the state gamma, extremely rapidly. A very striking illustration of this rapidity is given by the hardening of the upper surfaces of rails[15] by the heat developed by the slipping of the driving wheels. The friction heats the skin of the rail above the critical range into region 4, and the sudden cooling by conduction of heat down into the body of the rail prevents the gamma or beta iron thus formed from slipping back into the alpha state. Now, in some of Mr. Osmond's experiments he etched the metal with hydrochloric acid at 1000 deg. C. for five minutes and yet found the polyhedra of gamma iron contaminated with needles.

How is it possible that the beta state should persist under such conditions? Why was not the metal all gamma, and hence all polyhedra without needles?

The chain of evidence seemed complete. The specimen was introduced into a tube which had been previously heated to 1000 deg. and filled with hydrogen; five minutes were allowed for the temperature to reach region 4; hydrochloric acid gas was then passed through for five minutes at this temperature to etch the specimen; then it was stopped and hydrogen was passed through for 10 minutes, in order to drive out the residual hydrochloric acid and the resultant ferrous chloride; then the heat was cut off, and the specimen allowed to cool in the furnace in hydrogen. In order to preserve in the metal, after it has cooled, the gamma structure developed by etching while in region 4 it is, of course, necessary to prevent the etching from continuing after the temperature has descended below region 4 into the beta or alpha range. Mr. Osmond's precautions—driving out the ferrous chloride and residual hydrochloric acid for 10 minutes before starting to cool from 1000 deg., and then continuing the hydrogen, apparently as a stream, during the slow cooling from 1000 deg. to the lower boundary of region 4—seemed enough to prevent any appreciable etching influence from remaining when the metal finally passed below that boundary.

They seemed enough, but apparently they were not, because when Mr. Baykoff took the additional precaution of prolonging the passage of hydrogen for driving out the hydrochloric acid from the 10 minutes of Mr. Osmond to between two and three hours, the needle markings were no longer found, if we may judge from his illustrations and from his language. The inference from this is that Mr. Osmond's 10-minute sweeping out still left enough hydrochloric acid to etch the steel rapidly, and that when the steel cooled to below region 4 and changed from gamma to beta iron, the needle structure which we have so many reasons to regard as the structure of beta iron became developed by these unexpelled remains of hydrochloric acid. So this discordant evidence of Mr. Osmond's, which seemed to prove that the needle structure belonged to gamma iron is explained away really in a very simple way, and the theory that the needle structure represents beta iron becomes tenable.

When we have admitted this much with regard to these experiments of Mr. Osmond, we may go a step farther and accept a like explanation of the results less easily explained, which both he and Mr. Saniter reached. Both these gentlemen found that when steel was heated well into region 4 in molten calcium chloride and then quenched in water, it had the needle markings in addition to the gamma iron polyhedra. In one case Mr. Osmond heated his specimen for 130 seconds in calcium chloride, at the end of which it had reached a yellow heat, and then quenched it in water, when it still showed the characteristic martensite needles.[16] Now it would certainly be surprising if, as Mr. Baykoff assumes, the calcium chloride were able to etch the needle structure as deeply as it was etched in the calcium chloride experiments of both Mr. Osmond and Mr. Saniter, in the very brief interval between the time when the metal, while under water, cooled into the beta iron range and the time when it became too cold to be further etched. But then the needle markings may have been etched when the metal was heated up through the beta iron range, and they may have persisted unobliterated through the etching in the gamma iron state of region 4.

In Mr. Osmond's other experiments, in which the metal was cooled down slowly in the furnace, there would be plenty of time in the passage through the beta state for the residual hydrochloric acid to do its work of etching if we only make the reasonable admission that the structure does not leap from the gamma polyhedral state to that of pearlite, but passes through the martensite needle state. That under these conditions the metal should remain an appreciable time in the beta iron range is natural enough.[17] Were it not for this it would be impossible to harden steel by sudden cooling, i.e., to retain the martensite needles and harden the steel. The magnetic phenomena support this view.

Two straws may be noted which agree with this interpretation, that the needle markings in the specimens of Messrs. Saniter and Osmond are due to the action of the etching reagent while the metal was passing through the beta iron range into or away from region 4. These are as follows:

First, the slightness of the needle markings in Mr. Osmond's specimens etched with hydrochloric acid in a tube with subsequent attempt at expelling the hydrochloric acid before cooling below region 4 (Ar 3). The needle markings were so fine that they were not seen with a magnification of 25 diameters, though here the gamma polyhedra stood out very strongly.[18] This is as if the etching which had developed the polyhedra was very strong, while that which developed the needles was very weak, just such as we might expect from the small quantity of hydrochloric acid which would be left after his 10-minute sweeping out. This indication is of minor importance.

Second, Mr. Saniter,[19] in etching steels of different carbon contents in calcium chloride and then quenching in water, developed polyhedra alone without needle structure when the carbon content was 0.10, but, as the carbon content rose in his different specimens, the needle structure became more and more marked, and was very strong when the carbon content reached 1 per cent. In the same way Mr. Osmond notes that the martensite needles tend to disappear in pure iron, but their presence is favored by the presence of a little carbon.[20]

Now this is just what we ought to expect, on the theory that the needle structure is due to etching the metal in the beta state, whether in the rapid cooling from Ar 3 down or in the heating from Ac 2 up, because the higher the carbon-content the slower is the passage through that state. This is familiar to us all in the fact that the hardening power and the prominence of the needle markings increase with the carbon-content.

But, though Mr. Baykoff's evidence thus seems to me to make the theory that the needle structure represents the beta state tenable, and thus to give a simpler interpretation to all our evidence, yet I must admit that this evidence is really explicable on the other theory that these needles represent an assumed crystallitic state of gamma iron. This, like the beta state, would be one of transition between gamma and alpha. The needles represent transition; they may conceivably repre-

[15] E. Howard, Trans. Am. Soc. Testing Materials, VIII, p. 62, 1908

[16] Op. cit., XVII, p. 143, Pl. IV, Figs. 45 and 46.

[17] Compare Mr. Osmond, the Metallographist, II, p. 169, and the author, idem, II, p. 257.

[18] Osmond et Cartaud, Annales des Mines, XVIII, pp. 139-140, Pl. V, Fig. 8, Pl. VI, Figs. 1, 2 and 4.

[19] Journal Iron and Steel Inst., LII, pp. 124-5, Pl. V, 1897, II.

[20] Op. cit., XVIII, p. 145, 1900.

sent either the beta state or the crystallitic form of the gamma.

I point out this difference, that the proof of the existence of the beta state, in the excess of hardness, brittleness, and specific volume over both the gamma and the alpha states, and in the retardations at A 3 and A 2, is very strong, while the proof of the existence of the crystallitic state of gamma iron seems to me still lacking. It was invoked to explain away the apparent coexistence of the needle structure with the gamma state, a coexistence which has no longer to be explained, because Mr. Baykoff's results show that there may be no such coexistence. Nevertheless, should one postulate this coexistence and refer the needle marking to the crystallitic phase of the gamma state, he would be hard to silence, though he would have to explain how it comes to represent both the upbuilding of the gamma polyhedra out of the alpha state, and also the downfall of those polyhedra when the gamma changes back to the alpha state.

A crucial test of this question should be easy. Let one proceed, with all Mr. Baykoff's precautions, to etch low carbon steel, say, of 0.10 per cent of carbon, in the lower part of region 5 a. Here it ought to consist of envelopes of beta ferrite enclosing kernels or meshes of gamma iron (austenite). The carbon-content should be low, and the temperature but little above A 2, in order that the quantity of the beta ferrite should be large. The temperature should be rigidly stationary, lest the quantity of beta ferrite vary rapidly, dissolving in the gamma iron and again reprecipitating as the temperature rises and falls, with possible obliteration of the needle markings as fast as they form.

If the experiment is conducted skilfully, and if it is true that the needles represent beta iron, then the envelopes should have the needle markings, and the kernels should have the gamma iron polyhedra. In order to get large and hence easily identified envelopes of beta iron, it would probably be well to heat the specimen first in hydrogen to 1100°, and cool it down in the tube to slightly above Ar 2, holding it there till the end of the etching and of the subsequent outsweeping of the etching gas.

The inferences which I draw are as follows:

(1) The natural theory that the needle structure represents beta iron again becomes tenable.

(2) It is the theory to be adopted until disproved, because it is the simpler.

(3) On this, the probable theory, the needle markings found by Messrs. Osmond and Saniter indicate that the passage through the beta state in both heating and cooling is slow, as indeed Mr. Osmond's cooling curves had indicated.

(4) The theory that these markings represent the crystallitic state of gamma iron is still tenable, but it seems to introduce a needless complication in postulating such a crystallitic state.

(5) The truth of these two theories is easily tested by a crucial experiment, which I commend to our young men.

Calcium Carbide.*

By C. A. Hansen.

This work was undertaken with the intention of studying the reaction $CaO + 3C = CO + CaC_2$ with particular reference to the equilibrium CO pressure at various comparatively low temperatures.

Furnace.—The furnace used was one designed by Arsem, of this laboratory, and described by him. (*Jour. Am. Chem Soc.*, XXVIII, 922, 1906). A cut showing cross section is reproduced in Fig. 1. The furnace was calibrated against copper and platinum in the manner described by Arsem at 1 mm pressure and at 28 mm pressure. (See Fig 2.)

The copper was melted in a graphite crucible, the melting point taken as 1084 deg. C.

Copper 1 mm.		Platinum 1 mm	
Melting Pt.	Freezing Pt	Melting Pt.	Freezing Pt
2.5 kw	2.3 kw	5.0 kw	
2.5 kw	2.3 kw	5.0 kw	
Mean 2.4 kw		Mean 5.0 kw	
28 mm.		28 mm.	
2.6 kw	2.4 kw	5.1 kw	
2.6 kw	2.4 kw	5.1 kw	
Mean 2.5 kw		Mean 5.1 kw	

The platinum was melted in a thorium oxide crucible which was separated from the graphite crucible support by a tungsten washer and the melting point was taken as 1780 deg. C

The melting point is determined by the appearance of a black spot on the surface of the metal bead, a portion of the meniscus reflecting no light vertically through the mica window (*h*). The freezing point is determined by the disappearance of this black spot, due to wrinkling of the metal surface on solidifying. In the platinum determination the black spot refuses to disappear on cooling, so that only the melting point reading can be taken. In this case the platinum was considered at its melting point when the metal began to collect in beads on the wire used.

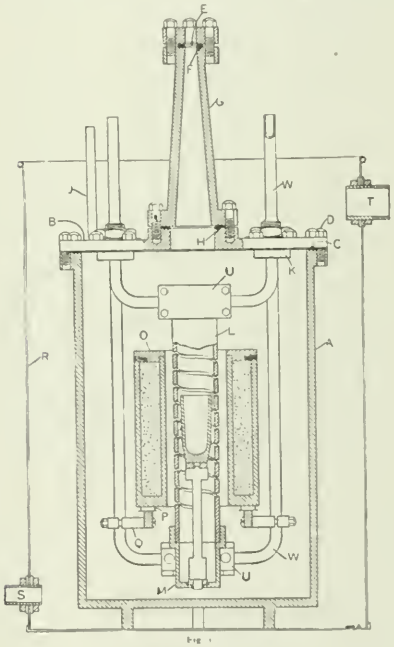

FIG. 1.—ELECTRIC FURNACE

The temperature, according to these determinations, falls off not more than 20 deg. at constant power input as the pressure increases from 1 mm to 28 mm when the mean temperature is about 1800° C

As a test for leakage, and gas in the graphite apparatus within the furnace, the furnace was sealed at the melting point of platinum.

Time, Minutes.	Kw	Pressure
0	5.0	1.0 mm.
30	5.	1.0 mm.
35	5.1	28 Let in air
65	5.1	28

As a further test for leakage the furnace was sealed cold on a Friday noon, at 1 mm pressure. The following Monday morning the gauge registered 3 mm pressure.

Exhausting Apparatus.—This consisted of a 5-10 mm pressure rough pump line and a Gryk pump with two cylinders in series, capable of reducing pressure to less than 0.5 mm. The furnace was always exhausted on rough vacuum line, then

*A paper read before the International Congress of Applied Chemistry, London, 1909.

shifted over to the Geryk pump. The Geryk had cylinders 2½-in. diameter, 5-in. stroke and operated at 35 r.p.m.

The pressure was measured on an ordinary mercury manometer

CO Test.—A small gas flame was allowed to play over the mouth of the pump exhaust tube. A pressure of 2 mm CO in the furnace results in spurts of characteristic blue flame, an inch or two in length when the exhaust gas was thus ignited.

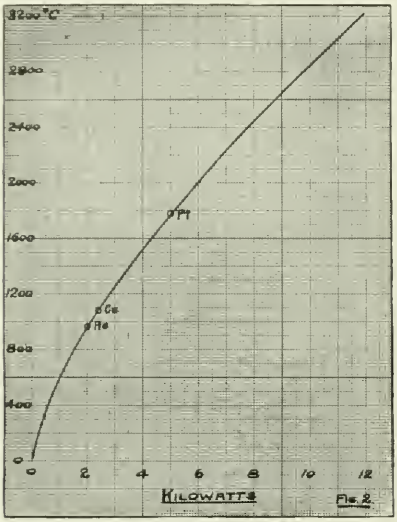

FIG. 2.—CALIBRATION CURVE.

Charge.—90 parts of pure lime, 38 parts of "1340" Acheson graphite, 50 parts hard pitch were ground to an impalpable powder in a small hardened steel mill. The powder was then ground to the consistency of a thick cream with Kahlbaum's c.p. benzol and dried to 150° C., with constant stirring. The final powder was then pressed, at about 40 tons pressure, into pellets 1 in. high and 1 in. diameter and carbonized by baking to 800° C. in a small electrically heated muffle. The object of using pitch and benzole was to thoroughly coat each lime particle with carbon and so secure a maximum contact surface between

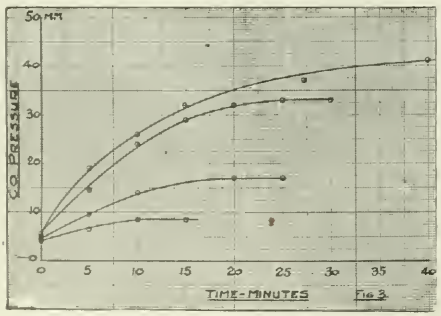

FIG. 3.—PRESSURE CURVES.

the reagents. A pellet so treated, then fired in a vacuum for four hours at 1000° C., to drive off any CO_2, hydrocarbons, etc., weighed about 16 grams and analyzed:

57.6 CaO
43.2 C

This corresponds to

57.6 CaO, 37 C } in proportion to form CaC_2
6.2 C excess

Procedure.—The intention was to heat a pellet to a definite temperature, seal off the furnace and take pressure readings, the equilibrium pressure being indicated by several consecutive equal pressure readings.

A pellet was introduced into the furnace, in a graphite crucible, heated to 1000° C. for four hours to insure complete removal of the CO_2 in the lime, volatile pitch hydrocarbons and the complete reduction of a small amount of Fe_2O_3 (0.2 per

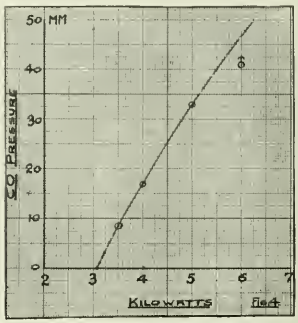

FIG. 3.—PRESSURE CURVE.

cent) in the pitch and graphite. The run then proceeded as follows:

Time.	Kilowatts.	MM. Pressure.	
9:00 a. m.	2.0	8	
1:00 p. m.	2.0	3	
1:00	3.0		
1:15	3.0	3	
1:15	3.5		
1:30	3.5	4	Shut off pump after pressure reading
1:35	3.5	6.5	
1:40	3.5	8.5	
1:50	3.5	8.5	Opened to pump after pressure reading.
1:53	4.0	4.5	
2:03	4.0	4.5	Shut off pump.
2:08	4.0	9.5	
2:13	4.0	14	
2:23	4.0	17	
2:30	4.0	17	Opened to pump.
2:32	4.5	6	
2:40	4.5	5.5	
2:50	4.5	5.5	
2:50	5.0		
2:56	5.0	5.5	Shut off pump.
3:01	5.0	17	
3:06	5.0	24	
3:11	5.0	29	
3:16	5.0	32	
3:21	5.0	33	
3:26	5.0	33	Opened to pump.
3:35	6.0	5	
3:40	6.0	5	Shut off pump.
3:45	6.0	19	
3:50	6.0	26	
3:55	6.0	32	
4:07	6.0	37	
4:20	6.0	41	Opened to pump.
4:25	6.0	3	
4:30	6.0	2	
4:40	6.0	1	Shut off power.

The increase in pressure with time during the various intervals when the pump was disconnected from the furnace is shown in diagram, Fig. 3.

It must be kept in mind that the contact surface between reagents decreased as the reaction progressed, so that the initial slopes of these curves are not a measure of the true reaction velocities at the corresponding temperatures. In fact, at the last the reaction velocity was so low that I did not wait for the equilibrium pressure to be established.

The equilibrium pressures are plotted against both kilowatts and temperature (as taken from Fig. 2) in Figs. 4 and 5. Exterpolated, these curves indicate reaction between CaO and C, at a temperature as low as 1275 deg. C.

Analysis of the product of this run:

42.7 CaC_2 (149.5 cc. C_2H_2 per gram)
3.0 CaO
50.6 C

The high carbon percentage necessarily means loss of calcium from the charge, either by direct distillation of calcium produced by the reaction $CaO + C = Ca + CO$, or by the formation and subsequent decomposition of CaC_2. In either case, the calcium and carbon would leave the crucible in atomic proportions, so it is possible, from analysis before and after firing, to calculate the disposition of the materials fired.

On the basis of a 100 gram charge, we obtain

7.7 g. C } not acted upon.
1.42 g. CaO }
20.1 g. CaC_2 recovered.
43.2 g. CaC_2 formed and decomposed, giving
27 g. Ca, which volatilized
16.2 C recovered.
27.7 g. CO pumped off.

According to this hypothesis the recovered carbide amounted to only 31.7 per cent of that formed. Loss in weight, 54.6 per cent.

To verify the results obtained in the first run, I attempted to show, first, that no reaction would occur at 1450 deg. C. if the pump were sealed off; secondly, that if the pump were

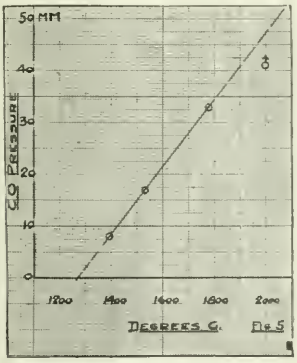

FIG. 5.—PRESSURE-TEMPERATURE CURVE.

connected and the CO pressure kept below the equilibrium value, the reaction *would* go on.

A pellet was treated at 1000 deg., as before, the furnace sealed at 1 mm, power increased to 3.7 kw (1450 deg. C.) and kept at this value for six hours. Analysis gave results identical with those on the unfired pellets.

The same pellet, less the analysis sample, was returned to the furnace and heated similarly for six hours, with the pump connected. The pressure ranged from 3 mm, at the start, to less than 0.5 mm at the end, and analysis showed

40.75 CaO
55.4 C

Less than 1 cc. of C_2H_2 was obtained from 0.5 gram of the product, although it smelled strongly of acetylene. The acetylene test was made immediately after removal of product from furnace. The pellet was then allowed to stand around in the atmosphere for a short time, which undoubtedly explains the incomplete analysis. The absorption of CO_2 and H_2O cannot alter the ratio of lime to carbon, so we are justified in increasing the values to

42.3 per cent CaO
57.7 per cent C

Disposition of 100 grams charge:

21.45 Ca } lost in furnace { volatile.
15.00 CO } { pumped off.

20.70 CaO } remained in crucible.
36.75 C }

It is perfectly evident that reaction does go on at 1450 deg. if the pressure is kept below the critical value, and that it does not go on if the pressure exceeds the critical value. We have not, however, shown whether calcium distils without forming calcium carbide, or whether the calcium carbide is formed, then dissociated. The residual carbon from the pellet, heated to 1450 deg. in the sealed furnace, obviously contained much of the gritty, amorphous carbon left behind by the pitch. The residual carbon from the pellet heated to 1450 deg. in the furnace with pump connected could be rubbed into a coherent, graphitic sheet with a spatula. This test is an unsatisfactory one for the formation and decomposition of CaC_2 in so far as the pitch carbon would be the first to be gotten rid of, because of the method of making up the pellet, even if the amorphous carbon would not be selectively oxidized.

A separate experiment was made in which I tried to dissociate commercial calcium carbide at 1450 deg. The carbide available was of rather poor quality, and the test unsatisfactory as a result of this poor quality. The carbide, before heating evolved 285 cc. C_2H_2 per gram. After firing six hours, at 1450 deg., it evolved 210 cc. per gram, and the loss in weight was 2.25 grams in 12.05 grams. Calculating the loss as calcium, the fired product should evolve 222 cc. per gram. Analysis of the fired product did not give nearly so satisfactory a result as the gas evolution. Apparently, the carbide was very non-uniform in composition. This work is to be carried on to a more satisfactory conclusion.

Thanks are due B. R. von Sholly, of this laboratory, for the analytical work.

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Schenectady, N. Y.

Mathematics and Physics.

In his presidential address, delivered to the British Association at Winnipeg on Aug. 25, Sir J. J. Thomson urges strongly the greater study of mathematics. We quote from his address as follows:

"The specialization prevalent in schools often prevents students of science from acquiring sufficient knowledge of mathematics; it is true that most of those who study physics do some mathematics, but I hold that, in general, they do not do enough, and that they are not as efficient physicists as they would be if they had a wider knowledge of that subject.

"There seems at present a tendency in some quarters to discourage the use of mathematics in physics; indeed, one might infer, from the statements of some writers in quasi-scientific journals, that ignorance of mathematics is almost a virtue. If this is so, then surely of all the virtues this is the easiest and most prevalent.

"Two points of view are better than one, and the physicist who is also a mathematician possesses a most powerful instrument for scientific research with which many of the greatest discoveries have been made; for example, electric waves were discovered by mathematics long before they were detected in the laboratory. He also has at his command a language clear, concise, and universal, and there is no better way of detecting ambiguities and discrepancies in his ideas than by trying to express them in this language.

"Again, it often happens that we are not able to appreciate the full significance of some physical discovery until we have subjected it to mathematical treatment, when we find that the effect we have discovered involves other effects which have not been decided, and we are able by this means to duplicate the discovery. Thus James Thomson, starting from the fact that ice floats on water, showed that it follows by mathematics that ice can be melted and water prevented from freezing by pressure. This effect, which was at that time unknown, was after-

...words spoken by his brother, Lord Kelvin. Multitudes of similar dependences of physical discoveries by mathematics could be quoted.

"I have been pleading in the interests of physics for a greater study of mathematics by physicists. I would also plead for a greater study of physics by mathematicians in the interest of pure mathematics.

"The history of pure mathematics shows that many of the

FIG. 1.—HORN LIGHTNING ARRESTER

most important branches of the subject have arisen from the attempts made to get a mathematical solution of a problem by physics. Thus the differential calculus arose from attempts to deal with the problem of moving bodies. Fourier's theorem resulted from attempts to deal with the vibrations of strings and the conduction of heat; indeed, it would seem that the most fruitful crop of scientific ideas is produced by cross-fertilization

FIG. 2.—FLAME FOR NITROGEN FIXATION.

between the mind and some definite fact, and that the mind by itself is comparatively unproductive.

"I think, if we could trace the origin of some of our most comprehensive and important scientific ideas, it would be found that they arose in the attempt to find an explanation of some apparently trivial and very special phenomenon; when once started the ideas grew to such generality and importance that their modest origin could hardly be suspected. Water vapor we know will refuse to condense into rain unless there are particles of dust to form nuclei; so an idea before taking shape seems to require a nucleus of solid fact round which it can condense.

"I have ventured to urge the closer union between mathematics and physics because I think of late years there has been some tendency for these sciences to drift apart, and that the workers in applied mathematics are relatively fewer than they were some years ago. This is no doubt due to some extent to the remarkable developments made in the last few years, in experimental physics on the one hand and in the most abstract and metaphysical parts of pure mathematics on the other. The fascination of these has drawn workers to the frontiers of these regions who would otherwise have worked nearer the junction of the two.

"In part, too, it may be due to the fact that the problems with which the applied mathematician has to deal are exceedingly difficult, and many have felt that the problems presented by the older physics have been worked over so often by men of the highest genius that there was but little chance of any problem which they could have any hope of solving being left.

"But the newer developments of physics have opened virgin ground which has not yet been worked over and which offers problems to the mathematician of great interest and novelty—problems which will suggest and require new methods of attack, the development of which will advance pure mathematics as well as physics.

"I have alluded to the fact that pure mathematicians have been indebted to the study of concrete problems for the origination of their most valuable conceptions; but though no doubt pure mathematicians are in many ways very exceptional folk, yet in this respect they are very human. Most of us need to tackle some definite difficulty before our minds develop whatever powers they may possess. This is true for even the youngest of us, for our schoolboys and girls, and I think the moral to be drawn from it is that we should aim at making the education in our schools as little bookish and as practical and concrete as possible."

The Innsbruck Plant for Nitric Acid from Air.

Besides the Birkeland-Eyde process and the new process of the Badische Company, which are both in successful commercial operation in Norway, there is a third process for the fixation of atmospheric nitrogen, working on a large scale in Patsch near Innsbruck in Tyrol. The water power of the Sill is utilized. The inventors of the process used at this plant are the two brothers, H. Pauling and G. Pauling, and the process is owned by the Salpetersäure-Industrie-Gesellschaft in Gelsenkirchen. The process has recently been described by Dr. FRANZ RUSS in a paper read before the Society of Austrian Chemists. The full paper is published in *Osterr. Chemiker Zeitung*, No. 11, 1909, and in the issue of Aug. 1 of the *Zeitschrift für Elektrochemie*.

The Pauling process employs arcs produced between two electrodes which are curved like the electrodes of the so-called horn lightning arresters (Fig. 1). The two horns are nearest together at the bottom and it is there that the arc is lighted. On account of the rising hot air the arc rises upward, becomes longer and is broken once for every half period of the alternating current. A new arc is then lighted at the bottom, and so on.

If an air current is blown with high speed between the electrodes of such a lightning arrester, the arc is still further blown away, so that it is possible to produce in this way arcs of considerable length. Fig. 2 shows such a flame arc of 200 kw capacity, as used on a large scale. In practice the minimum distance between the electrodes—at the point where the arc is

lighted—must be made large enough to blow the enormous quantities of air through. That means, the voltage required to light the arc over this minimum distance must be relatively high.

A special method of lighting the arc is used, as shown in Fig. 3. *a* are the two electrodes in horn form. At their lower

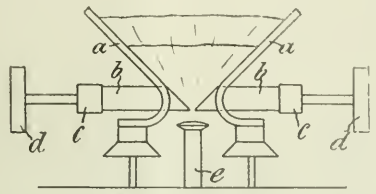

FIG. 3.—DEVICE FOR LIGHTING THE ARC.

end a slit is cut through each electrode and thin blades *b* are placed through these slits. The distance between the ends of these two blades can be adjusted by hand, by means of *d*, *c* being a piece of insulating material. Since these blades are very thin, they do not disturb the motion of the air and the latter can enter into the arc with full effect.

The main electrodes are so placed that an air current of about 40 mm width passes through the narrowest point. The preheated air-current is blown into the flame from a tube *c* in such a way that the air current, when leaving the tube, is diverged and passes along the electrodes along their whole length. The advantages of the thin blades are that the main electrodes *a* are absolutely fixed and that the flame may be easily regulated. Such a flame is electrically very "quiet" and appears to the observer to be stable. The length of the flame

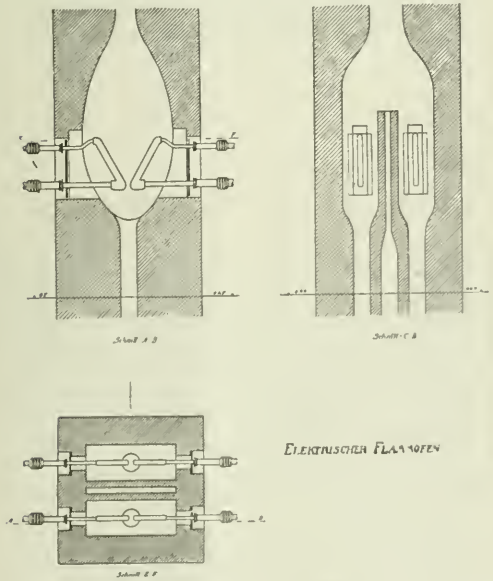

FIG. 4.—SECTIONS OF FURNACE.

in practice is about 1 m. The electrodes are made of iron and are water-cooled and their life is about 200 hours. The life of the thin blades *b* is shorter and it is necessary to push them nearer together from time to time so as to maintain the proper distance between their ends.

It is well known that the hot air containing nitrogen oxides must be cooled very quickly in order to prevent the nitrogen oxides from being again dissociated. This cooling effect is produced by passing "cooling air" into the upper part of the

FIG. 5.—FURNACE.

flame from the side. This "cooling air" is taken from the cooled gas mixture before it enters the condenser.

This "cooling air" is supplied into the flame at a lower speed than the main air current. It has a suction effect on the arc, so that the latter is lengthened and broadened.

By the Pauling process a concentration of about 1.5 per cent of nitrogen oxide is obtained on a large scale.

Each furnace built of brick contains two arcs. The type of furnace used at present is shown in three sections in Fig. 4. The capacity of such a furnace is 400 kw. while the voltage is

FIG. 6.—PORTION OF FURNACE ROOM.

4000. Six hundred cubic meters of air pass per hour through the furnace, not including the "cooling air."

At present 24 furnaces are in operation in the Innsbruck plant. Fig. 5 shows one of the furnaces and Fig. 6 part of the present furnace house. Fig. 7 is a view of a 400-kw flame.

Little attendance is required. One man is sufficient for six furnaces.

In order to supply a number of arcs from one and the same circuit a special arrangement is used (German patent, 193,366; Austrian patent, 30,533).

Two arcs are used in series in each furnace and there is a

very high resistance inserted between the center pole and one of the outer poles. The full voltage is therefore impressed first on the other side (between the other outer pole and the center pole) and an arc is formed there. The voltage in this arc then decreases quickly and almost the whole voltage is now impressed on the other side so that the second arc is started. In the moment when the second arc is lighted the circuit of the machine is directly closed through the two arcs in series so that a long arc can be formed.

More recently this method has been further modified. The voltage for lighting the arc is much higher than the voltage otherwise needed in regular operation. The voltage for lighting the arc is, therefore, now supplied by an auxiliary circuit of correspondingly high voltage, but of low wattage, while the

FIG. 7.—400-KW FLAME.

voltage for regular operation is less. Provision is made to prevent a discharge of the auxiliary high-tension circuit into the circuit for regular operation. It is possible to operate any number of furnaces in parallel from the same circuit, and this can be done satisfactorily without any disturbing effect of one arc on the others.

The gases pass out of the furnaces at a temperature of about 700 deg. C. to 800 deg. C. and are then transformed into nitric acid and sodium nitrite.

One of the most important technical problems—and at the same time a very difficult one—is the rational utilization of the heat contained in the furnace gases. This is used for preheating the air blown into the furnaces and for the evaporation of the nitric acid and the nitrite. The nitric acid is condensed in a system of chemical stoneware pipes and towers. An acid of 35 to 40 per cent is produced. For the concentration to commercial acid of 60 per cent, the heat of the furnace gases is utilized. The plant for making nitric acid is connected, as mentioned, with the plant for making sodium nitrite. In the latter the nitrogen oxides are utilized which still remain in the air after absorption with water.

Sixty grams of HNO_3 are produced per kw-hour in the Pauling process.

The 24 furnaces at present installed in the Innsbruck plant have a capacity of together 15,000 hp. Two other plants, each

FIG. 8.—NITRIC ACID WORKS AND ELECTRIC POWER PLANT.

of 10,000 hp, for carrying out the same process, are in course of erection, one in southern France and the other in northern Italy.

Current is obtained from the Sill water-power plant of the Municipal Electricity Works of Innsbruck.

An old view of the nitric acid plant and the electricity works is shown in Fig. 8, which shows the pipe line at the right, and

FIG. 9.—INNSBRUCK NITRIC ACID WORKS.

the nitric acid factory in the front. The two small frame houses are the experimental plant, while the large buildings are the 15,000-hp factory. Fig. 9 is a more recent view of the works.

Conductivity, Porosity, and Gas Permeability of Refractory Materials.*

By S. Wologdine and A. L. Queneau.

(*Concluded from page 383.*)

Porosity.

The porosity of clay products may be defined either by the volume of the pores expressed in percentage of the total volume[1] or by the ratio of the difference in weight between the weight of the sample saturated in water and the weight of the same sample dried in a steam oven, to the weight of the sample; this ratio is given in percentage of the dry weight.[2]

Let P_s be the weight of a sample dried to constant weight, P_m the weight of the sample saturated in water, and P_e the weight of the sample immersed in water. Then according to the second definition the porosity P_p will be

$$P_p = \frac{(P_m - P_s)\ 100}{P_s}$$

and according to the first definition

$$P_v = \frac{(P_m - P_s)\ 100}{(P_s - P_e) + (P_m - P_s)} = \frac{(P_m - P_s)\ 100}{(P_m - P_e)}$$

where $P_m - P_s =$ volume of the pores.

$P_s - P_e =$ volume of the matter without pores.

Knowing P_s, P_m, P_e, the true density (true δ) and the apparent density (apparent δ) are easily obtained.

$$\text{true } \delta = \frac{P_s}{P_s - P_e}$$

$$\text{apparent } \delta = \frac{P_s}{(P_s - P_e) + (P_m - P_s)} = \frac{P_s}{P_m - P_e}$$

To obtain P_s, P_m and P_e three weighings were necessary: First, of the dry specimen; second, of the same specimen boiled in water to expel all the enclosed air and then cooled in water under reduced pressure; third, of the same specimen saturated in distilled water.

The specimens used in these determinations, obtained from the bricks used in the heat conductivity tests, were of a form more or less regular and of about 10 gr. in weight; they were boiled in a beaker for an hour in distilled water, the beaker and contents were then allowed to cool under reduced pressure. If no air bubbles appeared during a second boiling, the sample after cooling was weighed in water by means of an hydrostatic balance. The specimen was then weighed in air in weighing bottles after carefully removing all superficial water with blotting paper; this determination of P_m was repeated several times; the different results were then averaged.

*A paper read before the London Congress of Applied Chemistry.
[1]Ries—Clays, 1906.
[2]LeChatelier Bulletin de la Société d' Encouragement, S.5, 1898, p. 1317.

TABLE III.

Conductivity, Density, Porosity and Permeability of Refractory Materials.

No.	Material	Mark	Conductivity: Gr-cal. per sq. cm. per cm., per 1° Diff.	Conductivity: Kg-Cal-Hr. per sq. m. per m. per 1° Diff.	Density: True δ	Density: Apparent δ	Porosity in % of Vol.	Permeability: Cm³-sec. per sq. cm. per cm.	Permeability: Lit-hr per sq. m., per m.	Temperature of Burning
1	Fire brick	1	.0030	1.07	. .	. .	. .	.0155	5.58	1.200°
2	" "	RA-5	.0037	1.32	2.61	1.81	30.8	.0409	14.72	1.050
3	" "	RA-9	.0050	1.81	2.5	1.9	24.1	.069	24.84	1.300
4	" "	RB-5	.0035	1.25	2.59	1.81	29.4	.105	37.84	1.050
5	" "	RB-9	.0042	1.50	2.55	1.78	30.2	.295	106.2	1.300
6	Checker brick	2	.0034	1.21	. .	. .	. .	. . . . .	. . . .	. .
7	"	4	.0039	1.42	2.65	1.91	27.8	.0465	16.74	. . .
8	Gas report brick	20-3	.0038	1.37	2.58	1.87	27.3	.0599	21.56	.
9	" " "	20-5	.0038	1.36	.	. .	. .	.0498	17.93	.
10	Bauxite . .	Bx-5	.0031	1.11	3.22	1.89	41.5	.0292	10.50	1.050
11	"	Bx-9	.0033	1.19	3.12	1.92	38.4	.212	76.39	1.300
12	Silica. . .	S-5	.0020	.71	2.75	1.58	42.58	.0092	3.32	1.050
13	"	S-9	.0031	1.12	2.62	1.50	42.9	.536	192.9	1.300
14	Magnesia.	M-5	.0058	2.08	3.07	2.0	35.1	.517	186.1	1.050
15	"	M-9	.0065	2.35	3.39	2.0	41.0	.0097	3.49	1.300
16	Euboea magnesia.	M	.0071	2.54	3.50	2.4	31.5	.015	5.40	. .
17	" and Vallauris clay.	MV-47	.0036	1.28	.	.	.	. . . .	. .	. .
18	" " " "	MV-50	.0035	1.27	.	.	.	.025	9.0	. . .
19	" " " "	MV 56	.0029	1.05	3.39	2.02	40.3	.0084	3.03	. . .
20	Glass pot*	P-1	.0025	.89	.	.	.	0	0	9
21	"	P-2	.0025	.89	2.65	1.86	29.7	.0008(?)	30	1.200
22	" " † . .	P-3	.0045	1.62	2.50	1.95	21.9	.0031	1.11	1.600
23	" " * . .	B-4	.0027	.96	2.52	1.77	29.4	0	0	.
24	" "	B-5	.0027	.96	2.53	1.71	30.4	.0028	1.02	1.200
25	Carborundum . .	CA-5	.0115	5.27	. .	. .	. .	. . . . .	. . .	1.050
26	"	CA-9	.0231	8.32	. .	. .	. .	. . . . .	. . .	1.300
27	"	C-5	.0033	1.20	3.02	1.96	35.2	.0053	1.90	1.050
28	"	C 9	.0145	5.22	2.83	1.96	30.6	.0043	1.55	1.300
29	Chromite. . .	Ch 1-23	.0069	2.48	.	.	.	.	.	.
30	"	Ch 1 36	.0066	2.37	.	.	.	. .	.	.
31	"	Ch-1 39	.0062	2.25	.	.	.	.	.	.
32	"	Ch-2 59	.0057	2.05	4.06	3.19	21.3	.0568	20.45	
33	"	Ch 2 26	.0055	1.98	4.03	2.98	26.1	.106	38.16	
34	"	Ch-2 45	.0047	1.69	.	.	.	. . . . .	. . .	
35	"	Ch 2 60	.0054	1.96	.	.	.	.	.	
36	Chromite, clay binder	FA 5	.0028	1.00	3.38	2.31	31.7	.0032	1.15	1.050
37	" " "	FA 9	.0034	1.23	3.38	2.49	26.4	.0075	1.7	1.300
38	" tar	P	.0025	.89	4.04	2.62	35.9	.0063	31.67	1.050
39	Kieselguhr.	K	.0018	.64	2.48	1.03	58.0	.0057	34.45	
40	Graphite. . .	QR 204/54	.024	8.64	2.42	1.79	26.0	0	0	
41	" . .	QR 204/68	.025	9.0	.	.	.	.	.	
42	Stone ware	GT-5	.0032	1.15	2.56	1.96	23.4	.0022	.80	1.050
43	"	GT 9	.0049	1.78	2.36	2.13	10.1	0	0	1.300
44	" "	G 41-5	.0031	1.10	.	.	.	. .	. .	1.050
45	" "	G 44-9	.0048	1.72	2.43	2.18	9.59	.	.	1.300
46	" "	G 152-5	.0034	1.22	2.41	1.93	19.05	.	.	1.050
47	" "	G 152-9	.0040	1.44	.	.	.	.	.	1.300
48	" "	G 189-5	.0038	1.37	2.57	1.91	25.5	.0047	1.68	.
49	Porcelain. .	PN	.0046	1.66	.	.	.	.	. .	1.400
50	" . . .	PD	.0043	1.55	.	. .	.	.	. . .	1.400
51	Sèvres stoneware	67	.0045	1.61	.	.	.	.	.	1.300
52	Building brick	TCB 5	.0043	1.20	2.48	1.98	19.9	.	.	1.050
53	"	TCP	.0037	1.34	2.56	1.91	25.7	.0015	.53	1.050
54	" "	T-5 5	.0035	1.25	.	.	.	.	.	1.050
55	" "	T 2-5 10	.0034	1.22	.	.	.	.	.	1.150
56	" "	T-5 [illegible]	.0028	1.01	2.54	[illegible]	23.0	.0021	.74	1.050
57	" "	T 3-5 12	.0035	1.26	.	.	.	.	.	1.050
58	Vallauris clay.	V-48	.0028	1.03	.	.	.	.178	4.1	.
59	" "	V-51	.0024	.86	2.55	1.71	32.9	.	.	.
60	" "	V-57	.0023	.83	.	.	.	.	.	.
61	Light clay. .	L 52	.0024	.86	2.60	1.[illegible]41	45.7	.0164	1.90	.
	"	4 58	.0023	.84	. . .	.	.	. . . . .	.	. .

*Green. †Burned for 6[illegible] days.

This method is only available for non-vitrified materials, in which the air bubbles are not completely enclosed in the glass-like material, as is the case with stonewares and porcelains.

The results obtained are given in Table 11.

Table 11. Density and Porosity.

Natural or Brick	Marks	Density		Porosity	
		True δ	Apparent δ	% in Weight	% in Volume
Fire brick	RA-5 31	2 61	1 81	17 08	30 85
" "	RA-9 30	2 5	1 9	12 1	24 1
" "	RB-5 20	2 59	1 81	16 12	29 44
" "	RB-9 24	2 55	1 78	16 0	30 2
Checker brick	2	2 65	1 91	14 5	27 8
Fire refort	20	2 58	1 87	14 5	27 3
Bauxite	Bx 5-10	3 22	1 89	22 0	41 49
"	Bx-9-15	3 12	1 92	20 0	38 4
Silica	S 5 14	2 75	1 58	26 98	42 58
"	S 9 13	2 62	1 50	28 63	42 90
Silica burned at 1400°	S 9 13	2 57	1 50	27 59	41 52
Magnesia	M 5 12	3 07	2 0	17 61	35 12
"	M 9 61	3 39	2 0	20 64	41 0
Euboea magnesia	M 53	3 50	2 40	13 15	31 52
Euboea, magnesite and clay	MV 56	3 39	2 02	19 93	40 32
Graphite	P 2 22	2 65	1 86	15 95	29 69
"	P 3 21	2 50	1 95	11 2	21 9
"	B 4 43	2 52	1 77	16 57	29 44
"	B 5 27	2 53	1 71	17 0	30 4
Carborundum	C-5 17	3 02	1 95	17 0	35 2
"	C-9 18	2 83	1 96	15 58	30 6
Graphite	P-9 10	2 37	1 7	16 7	28 4
"	QR 54 204	2 42	1 79	14 52	25 97
Chromite	Ch 2 59	4 06	3 19	6 7	21 3
"	Ch 2 26	4 03	2 98	8 75	26 09
"	FA 5 62	3 38	2 31	13 74	31 7
"	FA 9 63	3 38	2 49	10 6	26 42
"	F-9 64	4 09	2 62	13 0	35 9
Kieselguhr	K 39	2 48	1 03	57 0	58 0
Stoneware	G T 5 37	2 56	1 96	11 95	23 38
"	GT 9 29	2 36	2 13	4 75	10 10
"	G 44 9-25	2 42	2 18	4 39	9 59
"	G 189 5 35	2 57	1 92	13 29	25 46
White terra cotta	TCB-5	2 18	1 98	10 05	19 94
"	TCP-6	2 56	1 90	13 53	25 71
Red terra cotta	T-3-7	2 54	1 95	11 76	22 99
Vallauris clay	V 51	2 55	1 71	19 23	32 92
"	L 53	3 50	2 40	13 15	31 52

It is interesting to note the variation of density that takes place during burning and especially when in use in furnaces.

The density of silica brick burned at 1050 deg. was 2.75; it became 2.62 for the brick burned at 1300 deg., and 2.57 after long heating at 1400 deg. This increase in volume is due to the allotropic transformation of the quartz in trydimite. The change in density is accompanied by only a slight change in porosity.

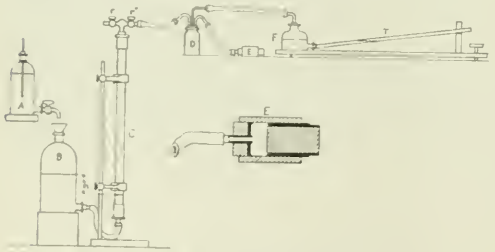

FIG. 7.—APPARATUS FOR DETERMINING PERMEABILITY

With the pure magnesia brick M, on the contrary, the change in density is accompanied by a marked change in porosity; the density 3.07 of the magnesia burned at 1050 deg. becomes 3.39 when burned at 1300 deg. The fragment of a magnesia brick from the Thiel lime kilns was shown to have this same density; the magnesia was distinctly crystallized, almost transparent, and very dense, its porosity was very low, 8.7 per cent against 41 per cent of the brick M-9. This change in the magnesia is doubtless an allotropic one, as yet not well understood. It will be shown further on that these allotropic transformations are accompanied by enormous changes in gas permeability.

It is of interest to remark that the graphite bricks with a rather high porosity, 25 to 28 per cent, are practically impermeable to gases. In this instance, as is the case with pure clays, the pores must be exceedingly minute.

Gas Permeability.

The lack of homogeneity in the plates, the presence of fissures, often invisible to the naked eye, rendered difficult the permeability tests. As will be seen, the permeability varies in a marked degree when the other physical properties vary but slightly; this is to be explained by the relatively large changes in the dimensions of the capillary pores due to the allotropic transformations of the clay, silica, magnesia, etc., which changes are usually followed by increase or decrease in the density.

The gas permeability is not a constant for a given specimen,

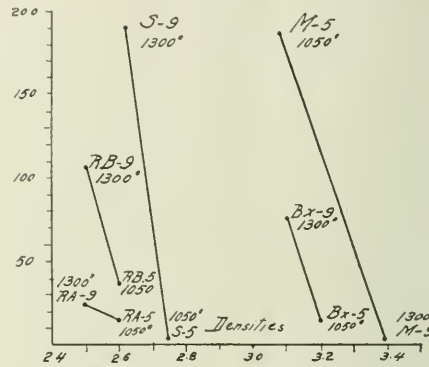

FIG. 8.—PERMEABILITY AS FUNCTION OF DENSITY

as it varies with the different axes. The permeability in an axis normal to the face of the plate is different from that in an axis parallel to the surface.

This phenomenon prevented the use of a very simple measuring method which consisted in the determination of the volume of air passing in a given time, through the thickness of the plate, when a known gas pressure is maintained in a tube applied to the surface of the brick under test.

By comparing the figures so obtained with the results of the determination made on small cylinders cut out of the same plates and enclosed in a glass tube, it was found that the ratio between the two sets of figures was so large as to exclude the influence of experimental errors.

Permeability to Gases.

Material	Permeability Lit. Sec	Ratio
Silica (S 9), directly	.109	...
" " in the cylinder	.302	3.4
Bauxite Bx 9, directly	.044	...
" " in the cylinder	.0127	3.5
Bauxite Bx 5, directly	.0054	...
" " in the cylinder	.0018	3.1
Fire brick RB 5, directly	016	...
" " " in the cylinder	.0063	2.5
" " RA-5, directly	.0069	...
" " in the cylinder	.0025	2.8
Magnesia M 53, directly	.0016	...
" " in the cylinder	.0009	1.7

In the above table are given the results obtained by the two methods.

It was thus necessary to select the second method, though it necessitated a long and tedious preparation of the specimens. Cylinders were cut about 40 mm in diameter and of the thickness of the plates; a coating of paraffin was applied to the cylindrical surface, leaving exposed the two parallel faces. It was necessary to avoid all air bubbles between the specimen and the paraffin and to prevent at the same time any penetration of the paraffin in the pores of the cylinder.

This was best attained by rubbing the cold cylinders with a piece of paraffin just about to solidify; in this manner the paraffin makes a good coating, at the same time freezing immediately upon contact with the cold brick.

Thus prepared, the cylinder is introduced into a glass tube,

the joint between the glass and the cylinder being carefully luted with paraffin to avoid any leaks when gas pressure is applied in the tube, the other extremity being closed by a rubber cork provided with a small glass tube.

In Fig. 7 is shown the apparatus used with bricks of small permeability.

The cylinder C, 55 mm in diameter and of about 2 liters capacity, graduated in cubic centimeters, served to measure the volume of air passing through the brick "G" in a given time.

The cylinder C was connected by its lower extremity with a bottle B, which received the water flowing from a Mariotte bottle A; the upper extremity of C, provided with two cocks

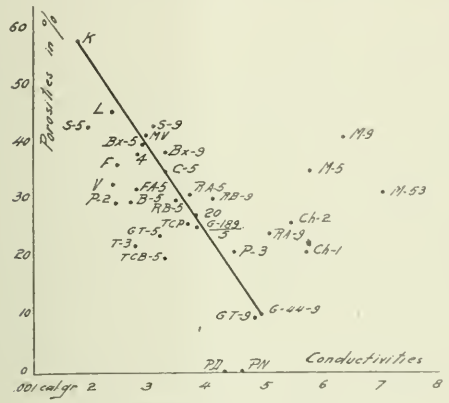

FIG. 9.—CONDUCTIVITY AND POROSITY.

r', r'', was connected with a flask D, which in turn was in communication with the tube E, holding the brick cylinder under test G, and with a manometer F, the tube of which T was inclined to a slope of 1 in 10.

For bricks of great permeability the tube C was replaced by a large gasometer graduated in liters.

Tests were conducted as follows:

The bottle B is lowered with cock r' open, thus filling C with air; r' is then closed and B raised to a height h, this giving a pressure p in the cylinder E; the pressure is measured by the manometer F; as the air passes through E, the head h decreases; to maintain it constant water is allowed to flow from the Mariotte bottle A. When a state of equilibrium has been established, the level of the water in the manometer T remaining constant, readings are taken of the water levels in C.

To detect any leaks through the paraffin coatings, the tests were repeated at least twice. For most of the bricks additional determinations were made by reversing the direction of the gas flow through the cylinders G, by turning them end for end in the glass holder E. All tests were repeated until concordant figures were secured.

The coefficient of permeability v is the quantity of air in cubic centimeters passing under a head of 1 cm of water in one second through a cylinder of 1 sq. cm cross-section and 1 cm in height.

For practical applications, the coefficient v may be better expressed by the number of liters passing in one hour through a surface of 1 sq. m 1 meter thick; this new coefficient is V.

Let g be the quantity of air in liters passing t minutes under the pressure p-p_0 (p_0 being the height of water in the manometer tube T corresponding to the atmospheric pressure) through the cylinder of cross-section s and length l.

The coefficient of permeability will then be

$$v = \frac{1000\,gl}{t\,(p - p_0) \times 60\,S} = \frac{16.667\,gl}{t\,(p - p_0)\,S}$$

In Table III are given the coefficients of permeability, v and V.

The coefficients of permeability are very different in the various bricks, and even in the same type of brick according to the temperature of burning, the size of the grains, etc.

For instance, the silica bricks burned at 1050 deg. have a permeability of 3.3 liters per hour, 192 liters when burned at 1300 deg., 241 liters when burned at 1400 deg.

A like change is seen in the fire bricks R B and R A, as well as with the bauxite bricks. This phenomenon is well shown in Fig. 8, giving the permeability in function of the true density before and after burning; the increase in the density is always followed by a decrease in the permeability. With the magnesia bricks, as the density increases with the temperature, so does the permeability, the same law being thus followed. Further, in the case of bricks where no increase of density results from the increase in temperature, there is also no appreciable increase in permeability.

Herr Simonis[1] reviewing the results that I recently published in the Bulletin de la Société d'Encouragement and the figures given by Nousselt[2] arrived at the following conclusion:

"The heat conductivity of clay refractories is that of the air enclosed in the pores and not that of the clay material itself."

The diagram of Fig. 9, in which the abscissas represent the mean conductivity of the different bricks, and the ordinates the corresponding porosity expressed in volume percentages, appears to confirm the Simonis rule.

From Fig. 10, which is diagram of Fig. 9 drawn on a smaller scale to include all the collected data, it will be noticed that the only bricks which do not follow the law are the chromite, magnesia, carborundum, and graphite bricks, which are not clay refractories. To the left of the straight line passing through the characteristic points of the diagram of Fig. 9 (K, B-5, G-180-5, G-44-9) are only the bricks of high heat conductivity (chromite, magnesia, carborundum, graphite).

Doubtless the porosity is not the only property that affects the heat conductivity of refractory materials. It may be added a priori that the degree of isolation of the air bubbles enclosed between the particles of the bricks, i.e., their gas permeability, must also affect the conductivity.

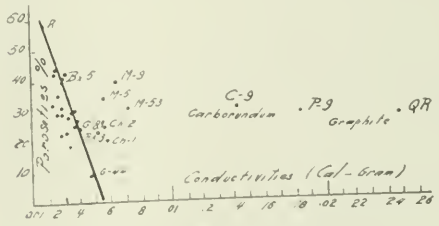

FIG. 10.—CONDUCTIVITY AND POROSITY

Permeability and Conductivity.

Material	Porosity %	Permeability in L. per Hr per sq. m	Conductivity kg-cal per Hr per sq. m
Glass pot, P 2	30.0	30	.09
B 5	30.1	1.02	.96
Fire brick, RB 5	29.13	3.84	1.25
RA 5	30.85	14.72	1.32
RB 9	30.2	106.2	1.50

Taking bricks of a like porosity, for example, 30 per cent. Fig. 9 (P-2, B-5, RB-5, RA-5, RB-9), it is seen that the permeability increases with the conductivity

The silica bricks with an equal porosity, 42 per cent. Fig. 9, appear to justify the same conclusion

[1] M. Simonis Beitrag zur Bestimmung der Warmeleitfähigkeit von Schamotteziegeln Sprechsaal, Jahrgang XXXXI, No. 40, 1908.

[2] Nousselt, z. des Vereines Deutsch. Ingen, No. 23, 1898, and Tech Mitheilungen, Nürenberg, July, 1906.

Permeability and Conductivity.

Material	Porosity %	Permeability in L. per Hr per sq. m.	Conductivity kg-cal. per Hr per sq. m.
[illegible]	42 58	3 32	71
[illegible]	42 90	192 9	1 12

Thus the conductivity increases when the enclosed air bubbles have the greatest maximum mobility; i.e., when the permeability is also greatest

Some Physical Characteristics of Iron Alloys.

By Charles F. Burgess and James Aston.

In connection with an investigation[1] of the properties of electrolytic iron and its alloys having a carbon content so low as to warrant their being considered as practically carbon free, the forgeability, welding and machining of these metals were tested and the results are summarized herein.

The basis of all the alloys is iron of a high degree of purity, obtained by a double electrolytic refining of commercial Swedish iron. This electrodeposited material has an impurity content of about 0.03 per cent, the iron by difference being 99.97 per cent. The desired amounts of this pure iron are weighed out, together with the proper percentages of the alloying elements, and placed in a covered magnesia-lined graphite crucible, which latter is buried in an electric furnace of the resistor type. After melting, an ingot is obtained of about 500 grams (1 lb.) in weight. Under these conditions of melting there is no agitation of the charge, nor is there any addition of the desired elements to the molten charge, and the resultant alloy is obtained entirely by diffusion of the elements, after being together brought to fusion from the cold state.

The ingots are heated in a forge fire and drawn out under a steam hammer into a rough bar from ½ in. to ⅝ in. in diameter and about 18 in. to 20 in. long, and from this the necessary test samples are obtained by turning or grinding.

The results of the above method of preparing the alloys are indicated by the agreement between the percentages of the alloying elements as added and as obtained by analysis of the turnings after melting and forging. Analyses of about 100 of the binary alloys show that very generally there is but little variation between the added and actual percentages, particularly among those elements which are most commonly used in alloy steels. In the nickel, copper and cobalt series this agreement is strikingly close; with tungsten, molybdenum, chromium, manganese and silicon it is reasonably so. In the last mentioned series, one alloy with an added content of 7 per cent Si showed on analysis only 3.33 per cent, but this variation is exceptional and not to be generally expected. Silver, selenium, aluminum and lead do not alloy at all in the proportions added; for silver this is particularly true, since the maximum percentage as analyzed is 0.697 per cent, while a maximum of 10 per cent was added. The most striking and unexpected instances are noted in the tin and arsenic series. Both of these metals vaporize at temperatures far below the melting point of iron. And yet we find very considerable amounts of the elements remaining in the alloy. For tin, the order of the series does not change, and about half of the added content remains; for arsenic, the agreement is very close up to an actual percentage of about 4, which seems to be the saturation limit, since for the alloys of 6 per cent and 10 per cent of added As the content has fallen to the above percentage.

Random analyses for carbon show small percentages, varying somewhat in the different alloys. Investigation leads us to believe that the greater part is due to the absorption of the carbon set free in the equilibrium reaction of iron upon the carbon monoxide gas of the furnace ($Fe + CO = FeO + C$). The amount of this carbon and other impurities is so small, however, that whatever properties are observed in the alloys may be said to be due to the addition of the various elements.

The notes given in the appended tables are the results of observations during the working of the ingots into test bars, and are qualitative, rather than quantitative. For the forging, we are indebted to Mr. Lottes, instructor in forge practice at the University, who has given a great deal of attention to the working of alloy steels. In case trouble was encountered in working at normal forging temperatures, different heats were tried to determine the best conditions. Upon indications of cracking or crumbling efforts were made to weld the bar, and the result noted. In general the welding tests were made upon a Thomson electric welder. The nature of the weld was determined by grinding the juncture and by testing with the hands. In many cases, no doubt, as Hadfield has aptly said, "the pieces may he stuck together and not truly welded, as a tensile test would soon show."

The machining tests include the nature of the material in the lathe, or its general hardness as noted in sawing and filing. All are in the condition resulting from forging, and without any annealing or other heat treatment.

In the tables the forging, welding and machining characteristics are arranged in three columns, and the various alloys are grouped alphabetically under the head of the predominating element. The observations were usually made and noted on each bar, but the results are given as a summary of the general effect of the alloying additions. The table is sufficiently explanatory to obviate the necessity of much discussion.

The forgeability of the various alloys does not differ greatly from that of similar commercial materials, qualitatively speaking; quantitatively, the effect of the impurities, especially the carbon content, will no doubt change the limiting ranges. Likewise, while carbon is conducive to the hardening by quenching of many of the alloys, and while it has its quantitatve effect upon all, it will be noted that chromium, manganese, molybdenum, nickel and tungsten promote self-hardening properties, even when carbon is absent. In fact, many of these last named alloys make satisfactory lathe tools, either in their air hardened condition or after quenching.

In addition to the materials listed in the tables, a large number of alloys were made up, of which the compositions and the results obtained are too diversified to enable systematic deductions to be drawn. These were very largely combinations of iron with several of the five elements mentioned above, and which are those generally found in self-hardening steels. They were very generally so hard as to require grinding into test bars, and practically all were forgeable with care in selecting the proper temperature, the precautions necessary being those usually taken in the working of high-speed steels.

Physical Characteristics of Iron Alloys.

Forging.	Welding.	Machining.
Electrolytic Iron.		
Easy. Brittle as deposited. Loses brittleness on heating to redness. Fused material can be worked cold. Forges well at all heats.	Easy in forge and also in electric welder.	Somewhat hard as deposited; can be easily machined, but is brittle. Like soft iron after heating or fusion
Aluminum.		
(2-½%) forged well at forging heat.	Did not weld in electric welder.	A1-Fe bars trifle harder than iron but turn easily.
(2.3%) forges at welding heat.	Did not weld in forge. Welds in electric welder. (2%) welds in electric welder.	
Antimon		
Alloys up to 10% made, but only that with 1% would forge. Rest crumbled.		No trouble in machining the alloy of 1% added Sb.
Arsenic.		
Alloys up to 4%. Forge well at normal heats. High As requires higher temperatures and must not be worked at dull heats.	All weld in electric welder.	Soft. Brittle at higher As content. Turns easily
Odor upon slight heating.		Marked odor even upon grinding bars.

[1] This investigation is being conducted in the Chemical Engineering Laboratories of the University of Wisconsin largely through a grant of the Carnegie Institution of Washington.

Forging.	Welding.	Machining.
Bismuth. Forged without difficulty, but Bi present in not more than trace, even though 10% added to charge.		Soft and easily machined. Bi content doubtful.
Cadmium. But one alloy made of 5% added content. Forged easily. Analysis showed no Cd present.	Welded in electric machine.	Soft and turned like steel.
Chromium. Alloys up to 22% added Cr made. Analysis agrees with added %. Forge easily at all heats, and can be worked at low temperatures. At Cr content of 10% they forge somewhat more difficultly.	But one Cr bar (1%) tested did not weld in electric machine.	The Cr and CrSi are in general hard, and are not put in soft condition by any annealing process.
Many CrSi alloys made, and in general forge well. Must be treated like self-hardening steels. They forge in all % Cr up to 20 or 30 and Si to several %. Forging becomes more difficult where Si reaches 3 or 4%. Temperatures used, a forging or yellow heat.	Many CrSi alloys did not weld in electric welder, but many others of about the same composition did. Evidently care needed to get right conditions.	
Further addition of Mo, Ni, or Mn to CrSi does not materially affect forgeability.	Cr + W + Si and Cr + Mo + Mn + Si did not weld in electric welder.	
Cr and Ni in all % up to 10 of each work well.	Cr + Ni in all % up to 10 of each will weld in forging.	
Addition of 0.3 to 0.5% V to alloys with up to 10% Cr did not affect forgeability.		Cr V alloys hard.
NiCr alloys up to 10% of each in alloy, together with 1 or 2% Si or up to 1% C, or a total of C + V = 1% forged well at normal temperatures.		These alloys were hard.
Most of the failures in forging are among Cr alloys + some other element. But in other cases alloys of like composition forged.		
Cobalt. Alloys up to 6% added and analyzed amounts agreed. Forged without difficulty at normal forging temperatures.	All were welded in electric welder except 6% Co.	Soft, except for 6% Co, which is slightly harder. But all can be machined in lathe.
Copper. Wide range of alloys of all compositions. Analysis agreed with added.	Low percentages (below 5) will weld in forging.	Lower % works easily.
Up to 2% forge well at low heats.	Also some bars of 7% welded in forge heating.	Somewhat harder with these % but work without difficulty. Hardness increases with increase of Cu. At 7% the alloy is very hard.
2 to 7% will not forge at low heat and poorly at white heat.	Up to 7% welded in electric welder.	
7% to 75—80% will not forge.	High % not welded	
80 to 100% forge at fair red heat but not at normal forging heat for iron.		
In earlier work, alloys above 5% could not be worked. In later tests, many alloys of 5 to 10% were tried at all heats. With care and a high heat (welding) a 7% bar can be forged (or even an 8% rarely).		High Cu alloys work like copper Drag on tool
80% Cu alloy forges somewhat cold and works well at dull red.		

Forging.	Welding.	Machining.
A 75% Cu smashed at dull red.		
Alloys of 5 Cu 1 Al 2 Cu ½" forged easily at high heat.	Also welded in forging.	Work easily in lathe.
But a 4½ Cu 4½ Al and a 10 Cu 4 Al smashed in forging. Likewise an 89 Cu 4 Al.	Several bars of 1 to 3% Cu and 0.5 to 1 Al welded in elec. welder.	
Two alloys of 2 As 3 Cu and 4 As 3 Cu forged at normal temperatures. The former checked badly and the latter broke in swage.	All of CuAs bars welded in elec. welder. 3 to 5 Cu and 1 to 4 As.	4 As 3 Cu brittle and hard. Also 2 As 3 Cu hard. Works easily in lathe.
The CuSi alloys worked with difficulty if Cu and Si rise to appreciable amounts. When total of Cu + Si exceeds 7% they forge with difficulty. One reported forged with 6.67 Cu and 6.67 Si, but no analysis to confirm these amounts.	1 bar 0.5 Cu and 0.25 Si did not weld in elec. welder. One of 3 Cu + 0.5 Si did.	CuSi alloys work easily like wrought iron.
At high Cu % (90 and above) the alloys do not forge if Si of 1% is present.		High Cu with Al or Si worked like Cu.
Lead. But one alloy of 3% added, but only 0.08% analysis. Worked at forging and welding heat cracked and finally broke in swage.	This one bar did not weld in electric welder.	
Manganese. Several alloys of manganese content up to 12% made. Analysis checked reasonably well. All forged without difficulty at forging and welding heats.	Bars of 0.50 and 4% Mn welded in electric machine. 12% bar did not weld.	Became hard at about 4%. 1 and 2% alloys machined with air hardening lathe tools. Others ground.
Molybdenum. Alloys up to 15% made. Analysis in agreement. Forges well at all heats. Generally worked at forging and low forging heats.		Hard, becoming very hard at 5% and upward.
Addition of 0.6 to 1.2 C to 8 to 10% Mo will forge with care Low forging heat. An ingot of 15% Mo 1 C did not forge.		Hard
An ingot of 10 Mo 2 Si forged at weld heat while one of 10 Mo 4 Si did not.	Also welds.	All hard.
Alloys of 5 to 10 Mo and 10 Cr forged at normal heat. Addition of 0.5C or V to this requires care in heating and working.		
A 10 Mo 2 Ni forged well		Hard.
Various alloys of Mo up to 10% with additions of 1 or 2% Mn or about 0.5 V or about this % V with up to 0.6 C forged well at normal heats		
Nickel. All percentages made from 0 to 100 Ni. Analysis checked closely. Lower percentages forge same as iron at normal forging temperature. Ingots sound, but usually beads on top, probably due to extrusion of last fluid material by contraction on cooling. Alloys of 25, 26, 28, 35, and 75% Ni were forged without especial difficulty, although in an earlier instance a 26% smashed at low and high heat. Could not forge a 100% Ni. In	High nickel alloys (one of 85% Ni) which tended to crumble at lower heats, were welded nicely at very high temperatures of working and the liberal use of borax. Bars with all percentages of Ni were welded in elec. welder, but some failures are noted between 18% and 35% Ni.	Soft at lower percentages Ni. Becomes of moderate hardness with 10% Ni, increasing to maximum at 20-30%. Can be machined with lathe tools for all compositions, though in hardest range it is with some difficulty.

Forging.	Welding.	Machining.
ater tests an alloy of 4% smashed, and one 34% partially. With extreme care and high welding heats, with the liberal use of flux and working only at the very highest temperatures, a good bar was drawn out of an 85% Ni ingot. This high heat is probably necessary for all high Nickel. There might be a critical range about 34% Ni (Fe_2Ni_3?) Magnetic and resistivity tests indicate this (also dilation tests of Guillaume).		
1% Ni with 2 to 10% Cr forges easily with low Cr. Rather hard with high Cr. High forging heat.		
10 Ni with 1 to 2% Si forged with difficulty. Also with 2 Si + 1 C		
10 to 25% Ni with 10 Mo + 1 C forged with difficulty. Also 10 Ni with 10 Mo + 2 Si.		
Ni-V alloys with 0.3 to 0.6 V and 5 to 10% Ni forged well at normal forging heat		Ni-V alloys hard. Can be worked with proper tools.
Selenium. Only couple of alloys of low Se content	Welded in electric machine.	
Silicon. Alloys of Si content up to 7%. Highest reported on analyzed bars 4.65%. Agreement fairly close. Works well, but for higher silicon great care must be used. Bars of 5% and 7% added Si worked at welding heat and light blows with liberal use of borax. A 6% bar smashed when working at 1 lower heats. Bars tend to shell and will not weld together.	All bars welded in electric machine. One failure noted but does not prove lack of weldability for this composition. With care, bars of lower per cent Si can be welded in forge with liberal use of borax.	Below 1% Si can be readily sawed and machined. Hardness noticeable above 1% in sawing, and at higher amounts of 6% to 7% Si the alloys are hard and very brittle. Can be worked with lathe tools, however.
An alloy of 2 Si + 0.8% C was hard to forge.		
Silver. Ingots made up to 10% added silver. Analysis shows maximum of but 0.6% Ag. Forges well at all heats.	All welded in electric welder. One failure noted with highest added Ag of 10%, but analysis shows little Ag, so no proof from this bar of lack of welding properly.	All bars soft, and machined without difficulty.
Tin Alloys of added tin up to 10% made. Above 5% added were lost in forging, upon being tried at forging and welding heats. Highest % by analysis 2.9 from ingot of 4% added tin.	3% added tin alloy welded in forging.	Higher tin alloys brittle.
These lower percentages work fairly well, but care must be taken in heating and in working, especially near the limiting per cent of forceability. Will not stand full welding or very low heats.	All bars welded in electric machine.	Works well in lathe. Somewhat harder than iron. Works like steel.
Addition of 2% As to 2% Sn makes non forgeable alloy		Hard and brittle
1½ Sn 4 Si smashed in forging and 3 Sn 5 Si cracked at all heats.		
1 Sn 2 Al worked with difficulty and 2 Sn 4 Al and 4 Sn 1 Al could not be forged.	Welded in electric welder.	
3 Sn 1 Cu 1 Al smashed in forging.		
A ½ Sn 1 Cu forged OK at high heat but not at low		

Forging.	Welding.	Machining.
3 Sn 0.2 P forged.	Also welded.	
Tungsten. Binary alloys up to 20% added W made. Analysis agrees closely.	All % weld in forging at welding heats.	Became hard with increasing % W until at 20% are very hard.
Forge nicely at all heats. Most of bars worked at normal forging temperatures.	All % welded in electric machine.	
5 to 15 W with 0.4 to 0.6 C forge at forging and welding heats.	Also weld in forging	Hard.
13 W 3 Mo 0.4 C forges at high heat.	Welds.	Hard.
18 W, 6 Cr, 0.6 C. 0.3 V 10 W, 10 Mo, 0.2 C, 0.3 V, 2 Cr, 16 W, 5 Mo, 2 Cr, 0.5 C, 0.3 V hardly forgeable, except with extreme care.		Very hard.
W-Ni alloys with about 5% W and Ni from 2 to 15% forged well at forging heat.		Hard.
W-V alloys of 4 to 7% W and V from 0.3 to 0.4% worked well at forging heat. Also addition of 0.2C did not affect forgeability.		Hard.
Vanodium. 2 bars of 0.2% and 0.3% added V. No analysis. Forge well at normal heat.		Bars a trifle hard Finish easily.

Chemical Engineering Laboratories
University of Wisconsin.

The Laboratory for Electro-Analysis at Purdue University.

By Edward G. Mahin.

Electro-analysis has reached the stage of a technical and exact science. The current is being used for accurate determinations, not only in works laboratories but for purposes of research as well, and the teaching of this branch of analytical chemistry has become a recognized and important part of the curriculum of every college which gives an extended course in chemistry. Purdue University has recently completed the equipment of a laboratory for this work and, as this installation is unique in many ways, a somewhat detailed description seems not out of place.

A few years ago the use of the electrical current in analytical work was so new and untried that apparatus could be installed for this purpose only after the most careful testing of every requirement. Now, however, thanks to the numerous researches of a large number of investigators and to the improved quality of instruments, it is possible to design a fairly complete laboratory that will meet every ordinary requirement. After a very careful consideration of the good and bad features of the various forms of apparatus already proposed for electro-analysis, plans were completed for the equipment of the laboratory at Purdue University, the entire apparatus being installed by the Central Laboratory Supply Company, of Lafayette, Ind.

Current is furnished by 5-plate Bijur storage cells, these being of the lead type, each having a capacity of 48 amp-hours and a maximum charge and discharge rate of 6 amp. They are placed in a closed battery case which is outside the room for electrolytic analysis. The cells are provided with sand trays and insulators, and also with glass covers which almost entirely prevent the annoyance due to acid spray during charging, and the case ventilator makes charging absolutely inoffensive. The interior of the case is protected against the attack of acid by asphaltum paint.

Wires from the cells run into the special laboratory where they are connected with the distributing switchboard. This is

a 28-in. x 72-in. board of black oiled slate, providing switches and plug receptacles for the control of all current which is used for any purpose within this room. The cells are connected in series groups of three each, the outside terminals of each group having double receptacles. This arrangement enables the operator to connect his cells with any number of groups in multiple, thus giving greater latitude in the selection of voltage and current strength than is possible with the usual series connections.

The 110-volt charging current enters the board through a switch which can be connected by plug connectors with any cell or combination of cells, and a slide-wire rheostat on the back of the board makes it possible to charge any number of cells at a time. The cells are protected during charging by an under-load circuit-breaker, and also during both charge and discharge by a fuse panel which is placed on the back of the

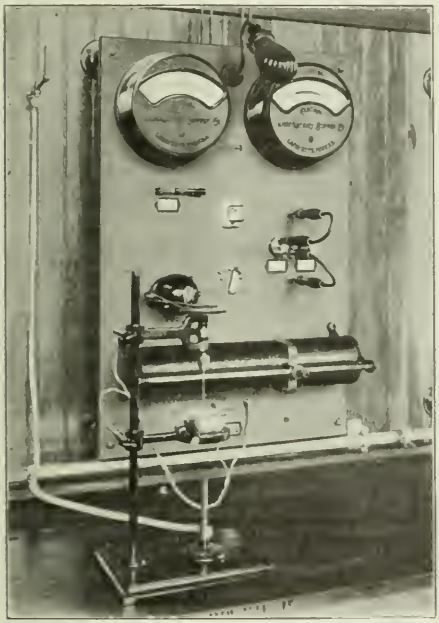

FIG. 1.—A SINGLE DESK PANEL, SHOWING ELECTROLYZING STAND AND ROTATOR.

board. An ammeter with a range of 20 amp and a double scale voltmeter, with ranges of 150 volts and 15 volts, are provided for proper control of the charging process. The 15-volt scale is used for testing the voltage of the cells when they are not in use.

A switch on the distributing board controls the 110-volt alternating current which is used for the lights and motors. Finally, on this board are the terminals for all of the desks, so that any operator may connect with his desk any of the cells not then in use, and in almost any combination. It will be seen from this brief description that the connections on this board make the different cells and desks practically independent of each other; for instance, a part of the cells may be charging while the remainder may be distributed to the various desks as wanted.

At each working desk is a 24 in. x 36-in. slate panel which carries all of the apparatus that will be needed by the analyst, making each board an independent working unit. The voltmeter and ammeter on each board are double-scale instruments with ranges of 2 volts and 20 volts and amperes, respectively. The multiplier for the voltmeter is controlled by a small knife switch, and the shunts for the ammeter are joined to plug receptacles. These measuring instruments are of such an unusual character as to deserve special mention.

Instruments which could be mounted in the usual manner on switchboards, but which would possess all of the features which make the superior accuracy of the best portable instruments, were desired for this purpose. The Central Laboratory Supply Company designed a special instrument embodying

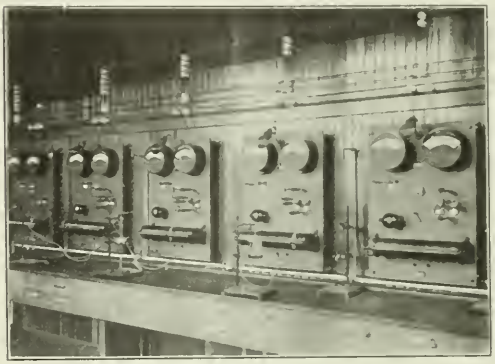

FIG. 2.—GROUP OF FIVE DESK PANELS.

these features. The case is of the switchboard type; the movement is of high grade and made with great care. The pointer is thin and is provided with a mirror background, making it possible to read without parallax. The scale is specially drawn with all of the care used in making the scales of high-grade portable instruments and the calibration has been performed with similar regard for accuracy. The whole case is sealed to make it air tight and is enameled in polished black, which not only gives it a handsome appearance, but also thoroughly protects the movement from the attack of acid fumes.

The current to each desk panel is controlled by a slide-wire taper rheostat of special design. The slide-wire type of rheostat was selected for this purpose because it provides in a small space a large amount of resistance in a large number of steps, conditions which, in a rheostat of the radial type, would require an instrument of such size as to make it decidedly cumbersome. These rheostats are wound to give a total resistance of 130 ohms, in 254 steps. The carrying capacity of the first step is 1.3 amp and that of the last step 25 amp. on continuous work.

FIG. 3.—STORAGE BATTERY CASE.

For working with rotating electrodes 1/30-hp. alternating-current, series motors of the commutator type are mounted on the board and are controlled by a switch and 5-step rheostat. Induction motors are not used, because it is desirable to make variation in speed possible. These motors have a maximum speed of 2200 r.p.m. on 110 volts and are provided with three pulleys of different sizes.

In many laboratories it is the practice to mount the motor directly on the electrolyzing stand, thus avoiding all belting and making possible direct connection with the rotating electrode. On the other hand, the application of a small belt is a simple operation and not only very much decreases the vibration of

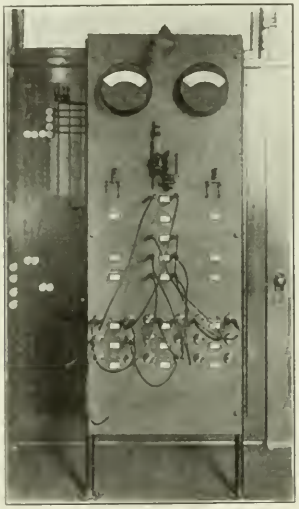

FIG. 4.—DISTRIBUTING SWITCHBOARD.

the stand, and consequently the danger of dust particles falling into the bath, but also removes the motor from the region of the bath, which in many cases contains acids and which is frequently hot. Corrosion of the motor parts is in this way largely prevented.

The stand for holding the electrodes is made according to our own specifications. It is of iron, is quite heavy, to prevent vibration, and is fitted with rubber feet. Every portion of the base and vertical rod is heavily enameled and the electrode supports are clamped to the rod by means of heavy thumb screws, but in such a manner that the screw does not come into contact with the rod, so that the enamel is not injured by the grip. Each clamp is insulated from the rod by a fiber bushing and each carries a binding post. There is no glass about the stand, perfect insulation of the electrode clamps being secured by the fiber bushings. The supporting ring for a dish cathode has three brass screw contacts which are adjustable for dishes of different sizes. Finally, for cone and spiral, or similar stationary electrodes, simpler clamps are provided to take the place of the rotator. The rotator, which carries three pulleys of different sizes, is a vertical shaft, the lower end of which carries a universal chuck, electrical contact being insured by a brass brush.

Practically every metal part of every piece of apparatus in the laboratory is protected against corrosion by heavy enamel, the only exceptions being the plug receptacles and the switches. The outward appearance of the whole installation is good and a thorough test has demonstrated the intrinsic merit of every part of it. It is believed that in thoroughness of design and in scientific care in manufacture the equipment of this laboratory is excelled by few in this country.

The Testing of Galvanized and Other Zinc-Coated Metals.*

By Dr. Wm. H. Walker

Three methods are now commercially used to coat iron with zinc. The oldest and for many years the only commercial method is the *"hot-galvanizing"* process, in which the iron article is simply dipped into a bath of molten zinc. The second is the *"wet"* or *"cold-galvanizing"* process, in which zinc is plated on the iron article by electrolysis from a solution of a suitable zinc salt. The third is the *"sherardizing"* process of Sherard Cowper-Coles, in which the iron article is heated in a closed chamber in the presence of finely divided metallic zinc and zinc oxide. (See our Vol. VI, page 189.)

Preece Test.—Although there is a marked difference in appearance and in structure between these three kinds of zinc-coated iron, only one method of testing them has been used, namely, the "Preece" or copper-sulphate immersion test.

As standardized by the American Telegraph & Telephone Company this test is essentially as follows: A standard solution of copper sulphate is prepared by agitating a nearly saturated solution of this salt with copper oxide until it is perfectly neutral. It is then diluted to 1.186 sp. gr. at 65° Fahr. When a rod of zinc and one of iron are placed in this solution the metals pass into solution as soluble sulphates, an equivalent weight of copper being at the same time deposited on the metallic rods. The copper deposited on the zinc surface is black, spongy and easily removed, while on the iron it is dense and of a bright color.

When this reaction is used in testing galvanized iron it is assumed that the speed of solution of the zinc is a direct function of the time of immersion, and by the number of one-minute immersions necessary to dissolve the zinc from the iron and to deposit a film of bright copper thereon, the thickness of the zinc can be estimated. It will be seen that this method measures the thickness of the coating only at its thinnest point, and that the assumption is made that no bright copper will be formed until the iron base is reached. To appreciate the limitations of this test, it is but necessary to note the structure of the three classes of zinc-coated iron.

A polished oblique section of ordinary hot-galvanized iron etched with iodine reveals three distinct layers. First, a coating of zinc, which varies in thickness in accordance with the temperature of the zinc and the amount of squeezing or wiping applied to the article before the zinc solidifies; second, a distinct layer of a zinc-iron alloy, termed alloy B, which varies in thickness with the temperature of the zinc bath and the length of time the iron was subjected to it; third, the iron base itself. Between the zinc and alloy B there is generally a second alloy, alloy A, which is a thin, discontinuous layer, richer in zinc than alloy B, and between the iron and alloy B is a third alloy, relatively unimportant, which is very rich in iron, alloy C.

The structure of wet-galvanized iron is comparatively simple, the layer being practically pure zinc.

Sherardized iron, on the other hand, presents a relatively complex structure. The metallic zinc penetrates the iron, forming deep layers of the alloys B and C, and in place of alloy A there occurs a number of compounds, as yet unidentified. Upon the surface there is generally a layer of relatively pure zinc, although frequently the process is carried to the point where only a deep layer of alloys is formed. When examined under the miscroscope this alloy is seen to be covered with deep cracks or fissures as though the alloy in forming had contracted. It is thus apparent that in testing galvanized iron made by these different processes we are dealing with three very different materials.

Desiderata for a New Test for Determining Durability or Resistance to Corrosion.—It is the purpose of this paper to treat of zinc-coated iron with regard only to its durability or

*Abstract of a paper read at the 1909 Atlantic City meeting of the American Society for Testing Materials.

resistance to corrosion, and not to its tensile strength. From this standpoint a test should, if possible, indicate the following: (1) The uniformity and thickness of the zinc coating; (2) the continuity of the coating with reference to pin holes; (3) the purity of the zinc, and (4) the toughness and ductility of the coating.

The corrosion of pure zinc in water is very slow. If, however, the zinc is in electrical contact with any material upon which the hydrogen can be liberated, the corrosion of the zinc is relatively rapid. The iron-zinc alloy *B*, and iron itself, are both surfaces on which this depolarization action can take place, and, hence, so long as neither the iron nor the alloy is exposed, other things being equal, the zinc coating will not corrode. The importance, therefore, of maintaining a uniform coating of metallic zinc upon the iron can be appreciated.

To determine whether the ratio of the time of immersion required to produce a bright copper surface was in reality a measure of the thickness of the zinc coating, samples of galvanized sheets were obtained and tested. The weight of zinc per square inch area was determined by dissolving the zinc from the sheets without attacking the iron-zinc alloy. This can readily be accomplished by heating the galvanized sample, together with a piece of metallic iron, in boiling caustic soda until the generation of the hydrogen ceases. As might be expected, the ratio between the time of immersion required to show the presence of bright adherent copper and the amount of zinc present per unit area depends upon the uniformity with which the coating of zinc is spread upon the iron base. In the case of 14 pieces of galvanized sheet iron, for example, the average ratio found was 23, while the greatest variation in either direction was but 20. This test, therefore, so far as indicating the uniformity of the coating and measuring the thickness of the zinc are concerned, is fairly satisfactory; but alloy B is always indicated as iron, and hence, when the test is applied to sherardized articles, very erroneous and misleading results may be obtained.

The presence of the channels or pin holes caused by the free iron surface coming in contact with the zinc and causing it to pass into solution cannot be detected by the copper-sulphate method, as these pin holes down through the zinc to the iron fill up with black, spongy copper and cover up the bright copper spot at the bottom.

The purity of the zinc cannot be determined, as the bright copper particles precipitated by this method are so small that they are lost in the mass of black, spongy copper.

Finally, the fourth factor, the toughness or the ductility of the coating, cannot be determined, due to the same tendency of the spongy copper to cover up the bright copper deposits, which indicate cracks extending down through the zinc coating to the alloy or iron underneath.

Test for Detecting Pin Holes and Cracks.—The relation between the presence of pin holes in the zinc surface and cracks due to a brittle coating and the durability of the structure as a whole has heretofore been studied, largely because no method of detecting these imperfections has been available. The following phenomenon serves as a basis for such a test. If a piece of zinc be placed in a strong solution of caustic soda heated to about 100° C. no action is noticeable. If now the zinc be touched with a piece of iron, hydrogen is liberated in great volume from the iron. Small cracks in the zinc coating may be easily detected in the same way.

Ordinary hot-galvanized ware is generally very free from imperfections of this kind, while wet-galvanized ware, on the other hand, is frequently very porous, generating hydrogen at numberless small points over its entire surface. Theoretically, the best electroplated surface should be that carrying the greatest weight of zinc per unit area, deposited at the slowest rate. That is, the lower the current density at the cathode in plating the less porous will be the deposited metal, and the thicker this dense deposit is the better protection will it be. A great many tests on electroplated zinc-coated iron were made, the samples varying in both these particulars. In every case, those deposited most rapidly were the most porous, and the results showed that the time of plating was more important than the weight of zinc per unit area, although there was a minimum below which it was not safe to go.

Test for Determining the Combined Effect of Imperfections.—As the rapidity of hydrogen generation from zinc is a function of the presence of an alloy of zinc and iron, hence the more impure the zinc coating, the more impure will be its solution in acid. Accordingly, the impurity of the zinc, the presence of pin holes and cracks, and the thinness of coating are all factors which act in an accumulative way to increase the rate at which hydrogen is generated when the zinc surface is exposed to acid. This method has been developed by Mr. Charles L. Campbell in his thesis for the B.S. degree at the Massachusetts Institute of Technology, and found to give very concordant results. The apparatus employed may take any convenient form, it being but necessary to expose a known area of the zinc coating to a standard acid solution under uniform conditions and to measure the hydrogen generated per minute. In almost every case a sharp maximum is reached giving the resultant of all the different factors which make for rapid dissolution of the zinc. Thus, in a series of wet-galvanized sheets, those electroplated for 15 minutes reached a maximum of 7 cu. cm in three minutes; those plated for 30 minutes a maximum of 14 cu. cm in 10 minutes, while those plated for 45 minutes showed a rather poor maximum of 6 cu. cm in 30 minutes. In many samples of sherardized product there were two maxima on the curve showing the amount of hydrogen generated per minute. This indicates that there is first an action between the outside zinc coating and the iron-zinc alloy, and later a well defined action between the alloy and the iron.

Service tests with galvanized iron are of necessity very slow at best, and the relation of the above phenomenon to the real durability of the material can be determined only after a number of years. Something can, however, be learned by the study of ware which has already been exposed for sufficient time to determine its durability. Most of the material available for the purpose was in the form of **fence wire**; from a study of these the following conclusions are drawn:

First, thickness of coating. In every instance where a very durable fence was found, the coating of zinc proved to be relatively very thick. On the other hand, the wire fences which showed marked corrosion in from one to two years proved to have almost no zinc on the iron, the zinc color being due to a layer of alloy alone. It is doubtless true that the purity of the iron used in the wire itself plays an important part in determining the ultimate durability of a fence, yet in the opinion of the writer the thickness of the zinc coating calls for more immediate attention. The modern method of close mechanical wiping the wire as it emerges from the zinc-bath produces too often a wire covered not with zinc but only a thin layer of electro-negative iron-zinc alloy, which affords but little protection to the iron. To produce a wire with a liberal coating of zinc would, of course, cost more both on account of the extra zinc and on account of a somewhat smaller production per machine

Second, purity of zinc It is probably a necessary consequence of hot galvanizing that the zinc becomes somewhat contaminated with dissolved iron. It is apparent that this should be kept at a minimum in order that the coating should be of maximum durability.

Third, flexibility of the zinc coating. The important objection to placing a thick coating of zinc upon wire used for fencing is that such a coating cracks off when running through the machine. This objection applies only to those wires which are subjected to very sharp bends or turns. It is possible that by passing the zinc-coated wire through dies or under grooved rolls that the crystalline condition of the zinc could be destroyed and the flexibility and ductility materially increased.

To sum up the results of this paper:

1. The copper-sulphate immersion test is of value in determining the uniformity of coating and relatively the thickness of coating in hot and in wet-galvanizing products; but it is worthless in the case of sherardized products, and gives no idea of other important factors involved in the durability of the structure.

2. By immersing a galvanized product in hot, strong caustic soda, the presence of any unprotected iron may easily be detected, however small such area may be.

3. The weight of zinc per unit area apart from the zinc-iron alloy may be analytically determined by dissolving the zinc from the plate through treatment with hot caustic soda while in contact with metallic iron.

4. Theoretically, the rate at which hydrogen is evolved when the galvanized product is immersed in dilute acid should indicate its relative durability; inferior products should reach a maximum in a few minutes compared with a much longer time for better products.

5. In the very important matter of fencing wire, while the purity of the iron used is of consequence, a more immediate necessity is a heavier coating of zinc on the wire.

6. The flexibility of a zinc-coated wire may possibly be increased by mechanically working the wire in rolls or dies to destroy crystallization in the zinc coating.

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The Laws of Electrode Losses in Electric Furnaces

By Carl Hering.

There are two kinds of losses which must be considered in electrodes; first, the loss due to the conduction of heat by the electrode from the material or gases in the furnace to the outside, which may be termed the heat conduction loss, or simply the thermic loss, and, second, the loss due to the electrical resistance of the electrode, which may be termed the electrical loss or the C^2R loss. Both losses originate electrically and are, therefore, of equal commercial value in cents per kilowatt, and both leave as heat and are, therefore, thermic; but the above distinction is useful for differentiating between them. For a given length, if the cross section increases, the heat loss increases while the electrical loss diminishes; while for a given cross-section the reverse is the case when the length is increased. Moreover, the thermal and the electrical conductivities of the particular material enter into the determination of these losses; and the total loss may be partly thermal and partly electrical, or entirely thermal or electrical, or even only a part of the C^2R energy. As these physical properties of the electrode material are an important factor, a comparison between two materials, like graphite and carbon, is evidently not a fair one unless each of the electrodes has its best proportions. The problem of finding the best conditions is, therefore, not a simple one.

The designer of a furnace is, therefore, required to know how these necessary parts of a furnace should be designed and proportioned so as to reduce the total loss inherent in them to the least possible amount; and, if there are any theoretically best proportions, how far is it practicable to approach them. Unless we know whether there are any such ideal proportions, and, if so, what they are, we are evidently unable to even approach them in designing a furnace.

The writer, therefore, concluded that the most satisfactory way to solve the problem is to make an analytical study of the subject in order to determine the laws which govern the best proportions. Having such laws, the designer can then determine how closely it is practicable to approach these ideals. As it appeared that no one had determined these laws, the writer some time ago undertook their deduction and found them to be as follows, and as they are absolute, under the assumed conditions, they may be properly termed the laws of electrode losses.

Laws of Electrode Losses.

a. The combined loss through the cold end of an electrode is equivalent to the sum of the loss by heat conduction alone (when there is no current) and half the C^2R loss.

b. This combined loss will be least when the loss by heat conduction alone is made equal to half the C^2R loss; the total loss will then be equal to the C^2R loss and no heat will be conducted from the interior of the furnace.

c. This minimum loss is dependent only on the material, current, and temperature, but not on the absolute dimensions; it merely fixes the relation of the cross-section to the length, but leaves a choice of either; hence

d. For economy of electrode material the length should be made as short as practical considerations permit.

e. For each material there is a definite minimum loss of electrode voltage which depends only on the temperature and is independent of the dimensions or the normal current for which the furnace is designed; hence,

f. The best possible electrode efficiency for any material may be determined from the total voltage of the furnace and this minimum voltage due to the material and the temperature, and is independent of the dimensions.

g. The heat gradient of the combined flow is equal to the sum of the heat gradients of the individual flows.

These laws are based on the following fundamental assumptions, any departures from which must be treated as correction factors: That the electrodes have a uniform cross-section throughout their whole length. That no heat leaves the electrode to the furnace walls or enters it from them; this is approximately true in most cases because the heat gradients are approximately the same in both, and there is contact resistance between them, which may be quite great. And that the temperature variation of the conductivities is approximately a straight line proportion. Neither of the two latter conditions seems to be accurately true, but the differences are probably small in comparison with the best possible degree of accuracy with which the best proportions of furnaces can be predetermined or realized in practice. Hence, great accuracy is not essential. The matter of importance for us to know is, in what direction to go to reduce the losses, and approximately what the minimum possible loss is, so that we can approach it as closely as practicable and do not waste efforts in trying to realize something which is impossible.

The conditions of minimum loss for a given normal current are illustrated in the following simple case: Let *ee*, Fig. 1, be an electrode surrounded by a perfect heat insulator except at its ends, which are kept cool, say, with a water jacket. Let a relatively large current be passed through it. This will heat it to a high temperature at the middle *m*. When the stable state is reached all the C^2R heat will flow out at the two ends, and none will flow across the middle section *m*.

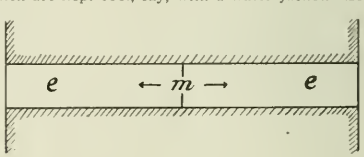

FIG. 1.—ELECTRODE.

If now this embedded electrode be imagined to be cut into two parts at *m*, and if these two parts are made the two end walls of a furnace with these conductors as its electrodes, as in Fig. 2, the temperature of the interior of the furnace being the same as that at *m* was in Fig. 1, it is evident that the heat flow will not be altered, while the same normal current flows, and that, therefore, there will be no loss of heat from the interior of the furnace through the electrodes.

That this is the condition of minimum electrode loss will be shown later.

The above laws will be further explained and illustrated in

the latter part of this article. The reason why they have apparently not been known before seems to be that the determination of the flow of heat in an electrode involves a problem in heat conduction which no one seems to have investigated, namely, the law according to which the conducted furnace heat and the C^2R heat generated in the electrode itself combine to flow out at the cold end. It is evidently incorrect to calculate each of these two flows of heat separately and add them to get the total, as was commonly done, because two quantities of heat flowing together in the same conductor change the temperature conditions under which each was calculated; and, as

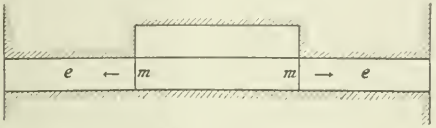

FIG. 2.—FURNACE WITH ELECTRODES.

was shown in Figs. 1 and 2, it is possible to make one of these act as a check valve, so to speak, to stop the other from flowing.

The fundamental law of the combined flows of these two dissimilar heats may be determined by the calculus, as follows:

Proof of the Fundamental Equation.

Let *ab*, Fig. 3, be a conductor of heat and electricity of uniform section, which is surrounded by a perfect insulator of electricity and heat except at its ends. Let the one end *a* be kept at a temperature *T* by some source outside of it, and the other end *b* kept at zero; hence heat will flow through it from *a* to *b*. In addition to this, let an electric current flow though it which sets free heat in its interior at a uniform rate in watts per inch. The problem then is: how much heat will flow out of the cold end after the stable state has been reached?

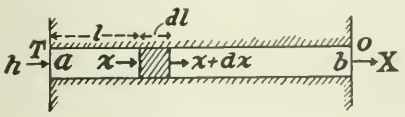

FIG. 3.—ELECTRODE.

Let:

X = total energy flow in watts passing out at the cold end.

x = total energy flow in watts passing through any section at a distance l from the hot end.

H = total heat flow in watts which would flow from the hot to the cold end when there is no electric current.

h = heat flow in watts which actually enters the hot end.

W = total heat flow in watts generated in the rod by the electric current; that is, the total C^2R heat.

w = this C^2R heat per inch of length = W/L.

T = temperature of hot end in centigrade degrees, when cold end is at zero, or the drop of temperature when it is not.

t = temperature at any given section at a distance l from the hot end when the cold end is at zero.

L = total length in inches.

l = any given distance from the hot end in inches

S = cross-section in square inches.

k = mean heat conductivity in gram calories per second for 1 in. length and 1 sq. in. section for the given range of temperature.

r = mean electrical resistivity in ohms for 1 in. length and 1 in. section, for the given range of temperature

C = the current in amperes.

R = the total resistance in ohms.

j = 4.186, namely the electrical equivalent of heat; that is: gram calories per second $\times j$ = watts.

Let *dl* be an infinitely short section at a distance l from the hot end, t be the temperature at the hot side of this section, and let the heat which flows into this section from hot end be x. Then, as the heat flow follows some law, the heat which flows out of that section is $x + dx$. Hence, the heat which has been added is the difference, namely, dx. But this heat, which has been added by the electric current, is also equal to wdl. Hence

$$dx = wdl \tag{1}$$

but

$$x = -jkS\,\frac{dt}{dl} \tag{2}$$

in which dt/dl is the heat gradient, which is negative because it increases as t diminishes. Differentiating, this gives

$$dx = -jkS\,\frac{d^2t}{dl^2}\,dl,$$

which combined with (1) and reduced gives

$$\frac{d^2t}{dl^2} = -\frac{w}{jkS}$$

Integrating this once, gives

$$\frac{dt}{dl} = a - \frac{wl}{jkS} \tag{3}$$

and a second time,

$$t = b + al - \frac{wl^2}{2\,jkS} \tag{4}$$

Now, when $l = L$ then $t = O$, and when $l = O$ then $t = T$. Substituting these values in this equation gives the values of the constants a and b as follows:

$$b = T$$

$$a = \frac{wL}{2\,jkS} - \frac{T}{L}$$

Substituting this value of a in (3) gives the value of the differential coefficient dt/dl in finite quantities; and this substituted in (2) gives the general equation for the flow of energy at any point l inches from the hot end:

$$x = \frac{jkTS}{L} - \frac{wL}{2} + wl \tag{5}$$

It will be seen that the first term is the total conducted heat H in watts when there is no current, the second is one-half the total C^2R heat, that is $W/2$, while the third term is the C^2R heat generated in the hotter part l. Hence, the general equation for the heat flow through any given section is

$$x = H - \frac{W}{2} + wl \tag{6}$$

Or, in other words, this means that at any point l inches from the hot end the flow of energy is equal to the total heat which would be conducted by the whole rod from the hot to the cold end in watts, when there is no current, less one-half the total C^2R energy per second in the whole rod, plus the C^2R energy per second generated in the part l.

Now, when $l = L$, then $x = X$, because it is then equal to the total flow out of the cold end; hence, as $wL = W$,

$$X = H + \frac{W}{2} \tag{7}$$

which is the fundamental equation sought. The heat which would be conducted from the hot end is

$$H = jkT\,\frac{S}{L} \tag{8}$$

and half the C^2R loss is

$$\frac{W}{2} = \frac{C^2r}{2}\cdot\frac{L}{S} \tag{9}$$

Hence, this fundamental equation means that the total energy flowing out of the cold end is equal to the sum of the heat which would flow if there were no current, and half the C^2R heat.

This equation may also be deduced by ordinary algebraic methods. It has also been checked by slightly different methods by Dr H. C. Richards and Dr. W. S. Franklin; it was also determined by a slightly different method, quite independently, though subsequently by Dr. E. F. Roeber.

Other Analytical Deductions.

If in (6) l is made equal to O, then $x = h$; that is, the heat which enters the hot end is

$$h = H - \frac{W}{2}$$

or, in other words, the furnace heat which enters is equal to the difference between these two heats. Hence, in order to make $h = o$, that is, to have this rod conduct no heat from the source at the hot end,

$$H = \frac{W}{2} \qquad (10)$$

or, in other words, the heat which would be conducted if there were no current must be made equal to half the C^2R heat. This is accomplished by proportioning the cross-section and length so that this equality results ,as will be shown later.

Returning to the heat flowing out of the cold end (7), it will be noticed that the product of these two terms is, from (8) and (9),

$$\frac{C^2jrkT}{2}$$

which does not contain the variables S and L, and is, therefore, a constant for any given conditions of a problem. But if the product of two variables is a constant, their sum (7) is a minimum when they are equal, and this sum X is then equal to twice either one of them. Hence, for the minimum flow of heat out of the cold end, that is, for the minimum total loss of energy in an electrode of a furnace,

$$H = \frac{W}{2} \qquad (11)$$

As was shown above in (10), this equality also exists when no heat enters the hot end of the rod; or in furnaces, when no furnace heat leaves through the electrode. The total loss is

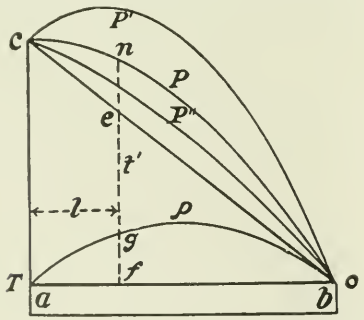

FIG. 4.—CURVES OF TEMPERATURE VARIATION IN ELECTRODE.

equal to their sum (7), but as they are now equal, this sum is equal to either $2H$ or to W. Or, put into words: *The total loss is least when the heat which would be conducted if there were no current is equal to half the C^2R heat; there is then no loss of heat from the furnace, and the loss through the cold end is equal to the C^2R loss.*

Returning now to the general equation (4) for the temperature t, substituting in it the values of a and b given just below it, and replacing wL by W gives

$$t = T - \frac{Tl}{L} + \frac{Wl}{2jkS} - \frac{wl^2}{2jkS} \qquad (12)$$

which is the general equation of the temperature, and, therefore, gives the heat gradient along the rod. It will be seen to be parabolic.

Making w equal to zero in this equation, that is, when no electric current is flowing, the heat gradient is a straight line Tcb, Fig. 4, in which ab is the conductor and a the hot end.

Making T equal to zero in (12) gives

$$t = \frac{Wl}{2jkS} - \frac{wl^2}{2jkS} = \frac{(W - wl)\,l}{2jkS} \qquad (13)$$

which is the equation of the parabola p, Fig. 4; this, therefore, is the heat gradient for the case shown in Fig. 1 above in which a rod is heated by a current while imbedded in a heat insulator, and is cooled only at the two ends.

It was shown above that the total loss of heat from the cold end is least when the conduction heat is equal to half the C^2R heat—that is, when the quantity (8) equals $W/2$. Making these two quantities equal, solving for T and substituting in (12), gives

$$t = \frac{WL}{2jkS} - \frac{wl^2}{2jkS} = \frac{w}{2jkS}(L^2 - l^2) \qquad (14)$$

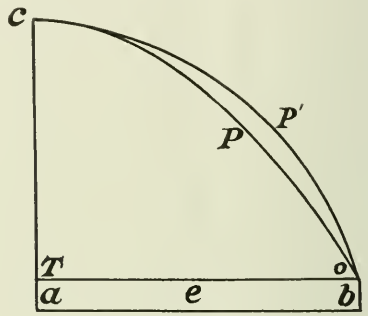

FIG. 5.—TEMPERATURE CURVES.

which gives the parabola P, Fig. 4. This, therefore, is the heat gradient for the case of minimum loss, which is the proper condition under which electrodes should be used.

Making $l = o$ in (14), then $t = T$; hence

$$T = \frac{WL}{2jkS} \qquad (15)$$

As this is the condition under which no heat flows into the hot end, this temperature is that due only to the C^2R heat W, hence this formula enables one to calculate the temperature to which the C^2R heat will raise a rod when no heat leaves it except at the one cold end. In practice this condition is realized in Fig. 1 when the electrode is considered to be half of the rod ee, from the middle m to either end.

It might be added here that if the heat conductivities k are known only for the two extreme temperatures, it is correct to use their arithmetic mean in the above formulas, except in the one for the heat gradient. This assumes that the conductivity varies according to a straight line law. This assumption, however, is not quite correct, but the error will then be only that due to the difference between the straight line law and the true one, which in most cases will probably be within the limits of accuracy of furnace calculations. But if the mean value is determined by means of (15), and then used in these formulas, the results ought to be correct and the errors ought to cancel each other, because the empirical value was then calculated with the same formula in which its value is afterwards used.

To introduce any other than a straight line law into the above equations would make them more cumbersome than the extra accuracy would seem to warrant.

There will be a slight difference in the heat gradient obtained when the conductivity is assumed to vary by a straight line law, and when a mean value is used, although the end results are the same. Fig. 5 shows the two curves; in cPb the conductivity is assumed to be constant (the mean value) for the whole range, and in $cP'b$ its true value is used for each point.

Conditions of Minimum Loss.

The fundamental formula deduced in the preceding part,

when stated in terms of the dimensions, physical properties, temperature and current, is:

$$X = 4.186\, k\, T \frac{S}{L} + \frac{C^2 r}{2} \cdot \frac{L}{S} \qquad (18)$$

For a given normal current at which the furnace is to be operated it will be noticed from this formula (18) that when, by proper proportioning, the heat conduction loss when no current is flowing (the first term) is made equal to half the C^2R loss (the second term) then the two terms are equal, and their sum is therefore equal to the total C^2R loss. This is the condition of minimum loss as was described above.

For a given length, the first term (heat conduction) increases as the section increases and in direct proportion; hence, in Fig. 6, this quantity is an increasing one represented by an inclined straight line *oh*. The second term, however (half of

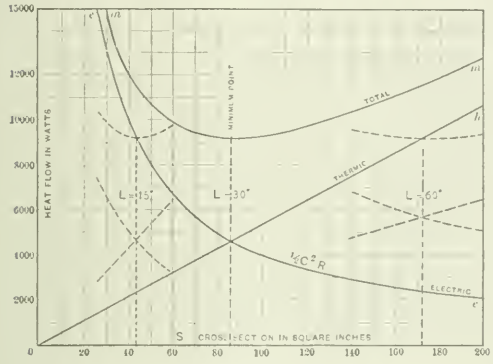

FIG. 6.—LOSS CURVES.

the electric loss), will decrease as the section increases, and in inverse proportion, hence this quantity is a decreasing one represented by the hyperbola *ee*.

The sum of two such quantities always has a minimum value, as is shown by the curve *mm*, which represents the sum of the two ordinates, and is therefore the curve of the values of X (in watts) in formula (18). It will be seen that this minimum point is reached when the two quantities are equal to each other—that is, at the point where the two lines intersect; it is, therefore, at this point that the conduction loss is equal to half of the C^2R loss, which is the condition stated above.

If the same sets of curves be drawn for several other lengths of electrodes, as shown in dotted lines in Fig. 6, it will be noticed that the total loss at the corresponding minimum point always has the same value, namely, the height of the upper curve measured at its minimum point. This means that the minimum loss is determined only by the material, the temperature and the current, and cannot be further diminished by changing the dimensions. It is, therefore, a fixed quantity, determined by the given conditions of material, temperature and current, and no possible change of dimensions can reduce it. To reach this minimum requires a certain proportion between the length and the cross-section, as will be discussed later, hence no further change of dimensions can possibly reduce it.

Let mX be this minimum total loss in watts. Making the two terms in formula (18) equal, solving for the ratio of S to L and substituting in (18) gives

$$mX = 2.894\, C \sqrt{krT} \qquad (19)$$

from which the minimum loss in watts can readily be calculated for any given case. The constant 2.894 is a purely mathematical one and includes no physical properties.

It is of considerable interest to note that this formula shows that this loss is independent of the dimensions and is fixed by the current, temperature and material (k and r). It is also of interest to note that it increases in direct proportion with the current and not with its square. It is independent of the amount of energy in the furnace, being a function merely of the current, which means that for a given input in kilowatts in the furnace the electrode loss becomes smaller if the current is decreased and the voltage increased. For a given normal current, material and temperature, the conditions are fixed, and the electrodes may be determined; the minimum loss then, of course, applies to this normal current and to none other, for if with the electrode thus determined the current falls below this normal, the loss will of course be less, but so will also be the energy in the furnace. What is said above, of course, applies only to the normal current specified for operating that furnace.

The formula also shows that the minimum electrode loss increases only as the square root of the temperature, and not as the temperature itself, as might at first be supposed. This means that the temperature may be increased considerably without increasing the loss greatly.

The same is true of the heat conductivity k and of the electrical resistivity r, either of which must be decreased considerably in order to better the loss appreciably. Hence, the choice of material is not as important a factor to reduce the loss as might at first be supposed, and such choice may, therefore, often be determined by other considerations, such, for instance, as size, convenience in handling, size of water jackets, terminals, etc., all of which will be shown to be far more favorable for graphite, for instance, than for carbon, although the minimum possible loss of energy seems to be slightly greater than for the latter. It will also be found that this minimum loss is in most cases quite small, much smaller perhaps than is generally supposed, hence a further reduction by reducing any of the determining factors in formula (19) should be carefully considered with respect to any possible attending disadvantages, chiefly as to size, as it may not be worth making. To reach this minimum loss with carbon, for instance, requires the electrodes to be far larger in section than for graphite (for a given length), and if not made of this much greater size the loss will not be the minimum, and hence may then exceed that of graphite. The differences between the minimum losses in these two materials (provided the best proportions can be realized in practice, which may not always be the case with carbon) does not seem to be great, yet the difference in the sizes is very great, as will be shown below.

Another feature should be considered. In high temperature furnaces carbon may graphitize partly, and if it was correctly proportioned at first, it will evidently not be so later on, hence the loss will then become greater again. Graphite is stable and does not change, hence, if correctly proportioned at the start, it remains so.

The resistivity r may be replaced by the reciprocal of the electrical conductivity K, and for comparing the qualities of materials as such the current and temperature may be made unity; the result will then represent the loss in watts per ampere for one degree of temperature, and will, therefore, be characteristic of the material itself. Making these substitutions gives

$$mX' = 2.894 \sqrt{\frac{k}{K}} \qquad (20)$$

K is in reciprocal ohms (mho) cubic inch units. This shows the interesting fact that the minimum loss depends on the ratio of the two conductivities; both may be large or both small, and yet give the same result, as far as the loss is concerned. The smaller this ratio, the better the material, as far as the minimum loss is concerned. Moreover, the loss varies with the square root of this ratio, which must, therefore, be considerably diminished in order to reduce the loss materially.

In order to improve materials for electrodes when this minimum loss is the criterion, the electrical conductivity should be increased as much as possible and the heat conductivity

diminished as much as possible, but it is their ratio that is the deciding factor, hence the heat conductivity may even be increased and yet the ratio may be less, if the electrical conductivity has increased still more in proportion.

There is still another interesting feature about this minimum loss. The loss represented by formula (19) is also equal to Ce in which e is the drop of voltage in one electrode. Making this substitution gives

$$e = 2.894 \sqrt{kT} \qquad (21)$$

which will be seen to be independent of the current, and which, therefore, means that for every material (k and r) there is a characteristic minimum drop of potential in the electrodes for one degree of difference of temperature, below which voltage it is not possible to go without again increasing the loss; and this is independent of the capacity, the dimensions, and even the amount of the normal current, the total drop being dependent only on the temperature. It might be termed the minimum electrode voltage of that material, as it is a characteristic property of it as an electrode material.

If by the term electrode efficiency is meant the voltage between the two inside or hot ends of the electrodes, divided by the voltage between the two outside ends, its highest possible value is determined by the total voltage of the furnace, the temperature and the material, and is independent of anything else. Hence, for any given electrode material and temperature drop, the furnace voltage necessary to give any desired electrode efficiency may readily be calculated.

This minimum electrode loss is not merely a theoretical ideal which it is impractical to reach, but it is an eminently practical result which could probably be readily reached in most furnaces, with graphite if not with carbon, if the data for its proper determination, namely, the two conductivities, exist. Attention should, however, be called to the flatness of this minimum curve *mm*, near its minimum point, which means that great accuracy in the proportioning is not necessary, as slight variations in the proportions in either direction will make only a small difference in the total loss. For instance, in the case shown in Fig. 6 a change of 10 to 20 per cent in the cross-section near the minimum point will increase the loss only about 1 to 3 per cent.

Proportions and Economy of the Electrodes.

Although the absolute dimensions of the electrodes are not fixed by the conditions for obtaining the minimum loss, yet the relation of the section to the length is. This is best shown analytically. If the two terms in formula (18) are made equal, which is the condition of minimum loss, the ratio of S to L is found to be a constant, determined by the material (k and r) the temperature and the current. That is, when

$$4.186\, kT \frac{S}{L} = \frac{C^2 r}{2} \cdot \frac{L}{S}$$

then

$$\frac{S}{L} = 0.3456\, C \sqrt{\frac{r}{kT}} \qquad (22)$$

This means that to get the minimum loss under given conditions of material, current and temperature the cross-section must merely bear a certain relation to the length as given by this formula. The interesting conclusion from this is that any number of different electrodes will give the same result, as illustrated in Fig. 7, in which all have the same ratio of section to length, as required by formula (22). The cross-section in all these is 10 times the length in inch units. It thus leaves one a choice of either the length or the section, but not of both, and this choice does not concern the loss of power; it merely affects the economy of electrode material. Practical considerations usually determine the length, and it is, therefore, generally the cross-section which is to be determined from formula (22).

Notice should be taken of the fact that the numerical value of this ratio will be different for different units, as, for instance, for inches and for centimeters; the actual sizes will, however, of course, be the same.

The rule concerning the economy of electrode material is, therefore, simply: *Make the electrodes as short as practical considerations will permit.* As the cross-section also diminishes with the length, the volume, or approximately the cost in dollars, diminishes as the square of the length. Hence the great importance of making the electrodes as short as possible when the economy of the electrode material is of importance; this choice of length will not affect the power loss and can, therefore, be decided on its own merits and without regard to the power efficiency.

For a given length the formula may be written in the form

$$S = 0.3456\, CL \sqrt{\frac{r}{kT}} \qquad (23)$$

which means that for a given length, temperature and material, the section increases in direct proportion with the current; hence the importance of producing the required heat in the furnace by as high a voltage as possible, so as to diminish the

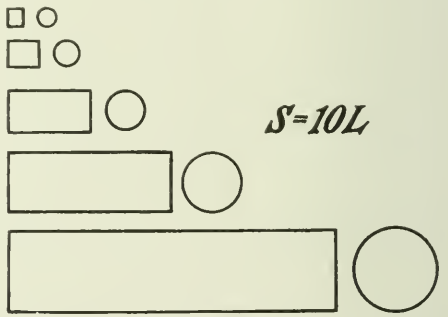

FIG. 7.—DIFFERENT ELECTRODES WITH THE SAME RATIO OF SECTION TO LENGTH.

normal current; this will not only make the electrodes smaller in the direct proportion as the current is diminished, but, as was shown above, it also diminishes the lowest possible loss of power in the electrodes, hence it is a double gain.

It will be noticed from (23) that the section diminishes as the square root of the temperature— that is, for higher temperatures it becomes smaller.

Letting the current density in amperes per square inch be represented by Cd, then formula (22) reduces to

$$Cd = \frac{2.894}{L} \sqrt{\frac{kT}{r}} \qquad (24)$$

which shows that the proper current density to obtain the best possible proportions varies inversely with the length, and, therefore, with the section; hence it is quite incorrect to proportion electrodes on the basis of a fixed current density, as is often done. For any assumed length, the resulting current density can readily be calculated from this formula so as to compare it with the maximum which the material will stand; if water-cooled at the outer end, it will stand much more, hence water-cooling results in an economy of material.

Making C and T equal to unity in formula (22) gives:

$$\frac{S}{L} = 0.3456 \sqrt{\frac{r}{k}} \qquad (25)$$

which shows that per ampere and for one degree temperature there is a definite best proportion of section to length for each material, which is a characteristic of that material and below which it is not possible to go in economizing the material without increasing the loss. Hence this figure affords a good means of comparison of different electrode materials when the economy of the material is the criterion. It shows that in this respect graphite is far superior to carbon, as electrodes of the former are very much smaller, as will be shown later.

Substituting in (25) the electrical conductivity K for the resistivity r, as was done in formula (20) for the convenience in making comparisons, this formula (25) reduces to

$$\frac{S}{L} = 0.3456 \sqrt{\frac{1}{Kk}} \qquad (26)$$

This shows that as far as economy of material is concerned, that material is best in which the *product* of the two conductivities is greatest. Hence, to improve a material in this respect either or both should be increased. But the improvement in economy is only in proportion to the square root and hence is not as great in percentage as the improvement in either of the conductivities.

Comparing this formula (26) with the corresponding one (20) for the minimum loss, it will be noticed that the requirements for economy in material (26) and for economy of power (20) are different, and in some respects antagonistic, hence the choice of the material depends somewhat on the relative importance of these two economies. With graphite and carbon, for instance, according to the best though crude figures available for the two conductivities, the electrodes become much smaller for graphite, but the minimum loss is slightly less for carbon, provided both have their best proportions and, of course, the same length. Hence the question arises, is it worth while to use the far larger carbons than the much smaller graphites in order to diminish an already low power loss slightly? Numerical examples will be given below.

In this comparison of (20) and (26) it will be seen that both economies are improved by an increase of the electrical conductivity alone, hence this is always desirable. An increase in the heat conductivity alone improves the economy of material, but diminishes the economy of power; a decrease in the heat conductivity alone, improves the economy of power but increases their size. The final criterion depends on their quotient and product, as was described.

Rules for Designing Electrodes.

From the above, the rules for the guidance of the designer may be briefly summarized as follows:

The temperature and the kilowatts are always given in the problem. The two conductivities or resistivities of the proposed materials must, of course, be available. From the kilowatts, make the current as small and the voltage as high as practicable. From formula (22) calculate the proportion of the section to the length. The length is generally fixed by the width of furnace walls or other considerations; the only rule is to make it as short as practicable, remembering that the volume and therefore approximately the cost diminishes as the square of the length; this length then determines the section. The current density (24) is not a factor in calculating the proportions of electrodes except in so far that it should not exceed practical limits.

The electrode loss will then be the minimum possible and is determined from formula (19) in watts; this is for one electrode and must, therefore, be multiplied by 2 to get the total The electrode efficiencies are then readily determined

These calculations should be repeated for each of the different materials available and the various advantages and disadvantages due to their different sizes, losses, terminals, etc., should be carefully weighed.

Never compare two electrodes of the same size but of different materials having different conductivities; such a comparison is unjust to either one or the other or both, as also to the designer, because it gives him an unwarranted confidence They can be properly compared only when both have their best proportions.

Numerical Examples.

To give numerical examples for illustrating these laws of electrode losses and their best proportioning requires that the two conductivities be known for those ranges of temperature. These constants, unfortunately, do not all exist in satisfactory form, but now that the laws of the electrode losses have been definitely established, these constants will no doubt be forthcoming in the near future. For the present, therefore, we must content ourselves with the best data that are available, but it must not be forgotten that the comparisons bas ed on them are no more reliable than the original data, and that the present results are, therefore, only approximate. The numerical examples are given here chiefly as illustrations and rough approximations, and not as accurate and reliable figures. But they are, of course, far better than those determined by the former methods based on current densities, the addition of the two losses, and on a comparison of electrodes of the same size but of different materials.

The electrical resistivity of graphite is probably quite close to 0.000333 ohm for 1-in. cube, taken lengthwise. But this is at normal temperatures; it falls quite appreciably at higher temperatures[1] reaching as low as about 64 per cent. A fair average for a range of temperature from 100° C. (water jacket) to 1700° C. (approximately that of iron furnaces) is therefore about 0.000266.

The absolute heat conductivity of graphite has apparently not been determined, notably not at the higher temperatures. According to FitzGerald it is 18 times that of carbon, while according to Hansen it is about 8 times carbon. Both are only relative and not in absolute units. The former figure seems to bring it up higher even than many metals and is, therefore, probably much too high; the second was determined under furnace conditions and is, therefore, probable more nearly correct. It will be so assumed here.

The heat conductivity of carbon is also not known. The only figure obtainable is 0.0103 in absolute units for retort carbon (about 0.026 in cubic inch units), which seems rather low for electrode carbons, which are certainly more like the metals than the vitreous retort carbons are. According to Hansen, it decreases at higher temperatures. It is, therefore, probably not far wrong to assume it to be 0.03 in cubic inch units. Graphite on the basis of 1 to 8 would therefore be 0.24.

The electrical resistivity of carbon seems to average about 0.00150 in ohm cubic inch units for the smaller sizes, but according to Hansen, it increases to 0.00337 for 6 in. × 6 in. and to 0.0055 and even 0.0100 for 18 in. × 18 in. As carbon electrodes must be very much larger than graphite, a comparison between the two becomes fairer if some account is taken of this higher resistance for the larger sizes; it may therefore be assumed to be 0.0025, and, as with graphite, that it diminishes with the temperature, making the average between 100° and 1700° C. about 80 per cent of this, which is 0.002.

Hence, the constants to be used here are, in cubic inch units, for a range of 100° to 1700° C.: graphite, $r = 0.000266$, $k = 0.24$. carbon $r = 0.002$; $k = 0.03$.

From formula (19) it will be seen that the minimum loss, as far as the material is concerned, is proportional to the square root of $k \times r$, which for graphite is 0.0080 and for carbon 0.0078; hence the difference in the losses will be only about 3 per cent in favor of the carbon.

Similarly from formula (22) the cross-section for any given length, as far as the material is concerned, is proportional to the square root of r/k, which for graphite is 0.0333 and for carbon 0.258, hence, for any specified furnace, carbon electrodes would have to have a cross-section $0.258/0.0333 = 7.75$, or nearly 8 times that of the graphite for the same furnace. The question, therefore, arises, is this very small gain in power worth the disadvantages of the enormously larger electrodes with their larger terminals, water jackets, etc.?

Let the capacity of a furnace be 500 kw and let it be decided to run it at 50 volts and 10,000 amp; the temperature to be 1700° C. inside and 100° C. at the outside ends of the electrodes From formula (19) the minimum loss in each electrode will, therefore, be 0.15 kw for graphite; hence the loss in the two

[1] According to figures obtained by the writer through the kindness of Mr. C. A. Hansen.

electrodes together, due to conduction and resistance, is only 3.00 per cent. For carbon it will be 8.96 kw or 3.58 per cent. It is to be noted how relatively small these actual losses are and what a small difference there is between graphite and carbon when they are properly proportioned. This difference is about 3 per cent of 3.55 per cent, or about 1/10 of 1 per cent of the total power. The curves of Fig. 6 are for the graphites for this furnace.

From formula (23) the cross-section for graphite in square inches will be 2.87 times the length in inches, and for carbon 22.3 times. Let it be determined from practical considerations that the length should be 30 in. and let the electrodes be round in section, then the diameter of the graphite will be 10.5 in., and that of the carbon 29.2 in. As stated above, the carbons will have nearly 8 times the cross-section of the graphites for the same length.

It will be seen that the carbon electrode will be about as large in diameter as it is long and is, therefore, entirely impracticable. For a length of 40 in. the diameters are 12.1 in. and 33.7 in. respectively; for 50 in., 13.5 in. and 37.7 in.; for 60 in., 14.8 in. and 41.3 in. and for 70 in., 16 in. and 44.6 in. In order to give a better idea of these proportions, they have

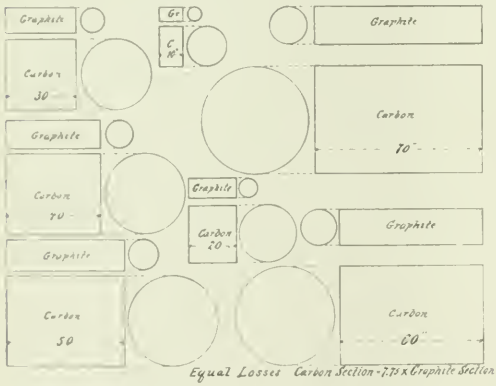

FIG. 8.—COMPARISON OF CARBON AND GRAPHITE.

been drawn to scale in Fig. 8 in pairs of the same length. For all these electrodes of the same material the loss is the same, that for the carbons being about 3 per cent lower than that for the graphites.

It will be seen what an awkward and entirely impracticable proportion the carbons have for such a furnace. To lengthen any of them appreciably for the same section, would increase the loss, and as the difference in loss is only 3 per cent, it would soon become greater than for graphite.

Hence the prevalent idea that the loss with graphite electrodes is always too great owing to their heat conductivity is a fallacy and is based on an improper comparison. As a matter of fact, it is their good heat and electrical conductivities that enable them to be made small and of such proportions that it becomes possible to obtain the minimum loss for such a large current furnace, which it is evidently impossible or at least impracticable to obtain with carbons, at least for this furnace, provided the assumed values of the conductivities are correct.

This illustration also shows quite strikingly the error committed when two electrodes of the same size but of different materials, are compared with each other. Either one or the other, and probably both, must have been badly proportioned; it was no doubt generally the graphite, which was much too large, and, therefore, naturally chilled the furnace. One can readily convince himself that these are the best proportions by changing either the length or the section, when it will be found by calculation that in every case the total loss will be increased. Formula (18) shows how this total loss may be calculated.

In comparing the quantities of electrode material (that is, the cost), one should, of course, compare the short graphite one with the much longer carbons, because the latter cannot be handled unless made sufficiently long. If, for instance, the shortest practicable carbon is 40 in. long, and graphite 20 in., the quantity of material in the former will be nearly 32 times as great. The drop of voltage in these electrodes, which is the same in all those of the same material, is determined from formula (21) or more directly from the above minimum loss, which was found to be 3.66 per cent for the graphite, hence $0.0366 \times 50 = 1.83$ volts, or 0.92 per electrode; and for the carbon 3.58 per cent or 0.90 volt per electrode.

Formula (21), of course, gives the same results, but to illustrate its application as giving the characteristic voltage drop of the material, substitute the constants for graphite and carbon, and make the temperature unity. This gives for graphite $e = 0.0231$, and for carbon $e = 0.0224$ as the characteristic minimum voltage drop for one degree for these materials. These are independent of the normal current for which the electrodes are designed—that is, they are the least voltage drop for any normal current, and are for one degree difference of temperature. Hence, the minimum voltage drop can be determined for these materials at once by simply multiplying these figures by the square root of the temperature. In the present case the temperature drop is 1600; hence, multiply by 40, which gives 0.92 and 0.90 as the two drops in voltages per electrode, regardless of which of the sizes of electrodes are chosen.

In conclusion, the writer desires to repeat that there are, of course, many other considerations besides the mere power loss and economy of electrode material which should be taken into consideration in the design of electrodes, some of which may at times outweigh the latter in importance; this depends on the particular conditions of the case. It is the duty of the designer to properly weigh all the various factors; he can, however, do this intelligently only when he knows what the ideal results are; the intention of the present investigation was, therefore, to assist the designer by showing what the best results are as far as it concerns only two of the many factors, the size of the electrodes and the power loss in them; the intention was not to attach undue importance to these two factors over the others. If, for instance, the consumption of an electrode in an arc furnace is in proportion to the quantity of electricity, it may perhaps be a distinct advantage to make them large so as to reduce the speed of feeding. If so, the above analysis will show that in such a case the length of the embedded electrode should be proportionally increased or else the power loss will become greater; it also enables one to determine what this increased power loss would be, and, therefore, whether it is worth saving.

PHILADELPHIA, PA.

Notes of Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

Autumn Inertness.

The scientific institutions have, as is usual at this period of the year, suspended their meetings; and the official reports of the proceedings of the British association at Winnipeg have not yet come to hand. The exhibits at the Imperial International Exhibition do not present much that is new, and, generally, lack the interesting features of last year's. The Cowper-Coles Engineering Company is showing some noteworthy specimens, and demonstrates the processes employed in the welding of aluminium, a regenerative method of electrodeposition, and a process of "vapor-galvanizing."

A New Method of Galvanizing Iron and Steel Tubes.

A well-know firm, makers of wrought-iron and steel tubes, holds the patent rights in Great Britain for tubes of a new cold process of electrodeposition for which many advantages are claimed. The pure zinc is deposited in a very minutely divided condition on the suitably prepared surface in a manner which appears to result in amalgamation. The evenness of the coating is maintained over the whole of the interior and exterior surfaces, including threads, and any variation of density is said to be impossible. The deposited zinc is so firmly united with the iron that tubes may be bent after galvanizing without any scaling or flaws occurring, which could not be done with tubes coated by the hot process.

Greater durability is said to result from the evenness of the coating, together with maintenance of the full capacity of the bore, and greater protective efficiency is ensured by the rise of zinc having a high degree of purity. Defects are not concealed by this process, as is so frequently the case with the old method, and pitting, flaws, and other faults show up as plainly after coating as before.

It is further claimed that the new method tends to enhance the malleability of the metal, while the hot process causes brittleness. Finally, all the advantages mentioned are secured without any increased cost.

New Regulation for Tinning Works.

In February and March of this year a public inquiry was held, and the report of the commissioner, Mr. E. T. Lawes, has resulted in the issue by the Factory Department of the Home Office of regulations relating to the tinning of metal goods, such as iron drums, hollow-ware and harness furniture. The coating of metal articles with tin or with a mixture of tin and lead has been classed as a dangerous occupation, and the regulations—which, with one exception, come into operation on Oct. 1, 1909—are issued under the Factory and Workshop Act, 1901. The exception is the regulation providing that tinning shall be effected under adequate ventilation for the removal of fumes or dust, and this will take effect on April 1, 1910. Employers are required to provide lavatories with requisites for the same; and also, if the works be not closed during meal hours, a separate room for taking food. The employment of persons under 16 years of age is prohibited. Dipping-bath skimmings, floor refuse, and dust must be removed from every workroom, while the employees are to wash their hands before eating food or quitting the works, and are forbidden to prepare or consume food or drink in any room used for the process of tinning. Periodical medical inspection of the employees is provided for and the chief inspector of factories has discretionary powers as to exemptions.

A Regulator for Alternators.

A device resembling the compound or series winding in direct-current dynamos, in order to secure constant voltage under varying load, has been introduced in Messrs. Parsons' patent compound-wound alternator. This improvement is consequential on the application of the well-known fact that although an alternating current does not produce a uni-directional field it may exert considerable influence in concentrating the same. If, then, a "keeper" be applied to the magnet poles while a strong current flows through the windings, it follows that when the sectional area of the "keeper" is less than that of the limbs, the iron "keeper" will be more saturated than they. If the current be alternating, such saturation will prevent any great increase of leakage flux in one direction, but will at the same time lessen it very greatly in the reverse direction, thus reducing the leakage flux to a very great extent. In Messrs. Parsons' machines the leakage-path windings are disposed between the alternator windings and the neutral point, and their insulation is calculated for the full pressure in the main windings. The additions are strictly electromagnetic, without movable parts, varying contacts, solenoids or other such contrivances. No commutator is required to convert the bi-direction current into the direct current. The machine can be utilized in the ordinary way in event of mishap in the new apparatus by removing it—which can be effected in a few minutes.

Marble Panels and Dampness.

The effect of dampness on marble panels is stated, in a recent issue of *La Nature* to have serious consequences. On several distribution boards at 110 volts leakage to earth was directly due to the marble being in contact with damp walls. In one installation with a normal insulation resistance of 300,000 ohms the actual resistance never exceeded 25,000 ohms in consequence of a lightning arrester being fixed to a damp wall, while the marble had absorbed such a large quantity of moisture that the loss to earth was easily shown by a galvanometer. In another case electrolytic action, caused by the moisture and the conductance of the damp marble, totally destroyed the copper plate of a lightning arrester connected to the positive pole of the line. Sulphate and carbonate of copper were formed and penetrated deeply into the marble panels, while the fixing screws were destroyed. It is clear that marble is not an efficient insulator unless protected from dampness. Direct contact with walls should not be permitted, and the deleterious effects of moisture can be averted by the use of packing pieces of paraffined wood coated with shellac with porcelain insulators interposed between the marble and the wood to secure circulation of air.

British Exports.

The values of the exports from Great Britain during the six months ended June 30 were: Iron and steel and manufactures thereof, 18,333,333; other metals, 4,000,000; machinery about 14,000,000. During June exports of iron and steel and manufactures thereof amounted to £3,073,091; other metals, £632,876; machinery, £2,304,092. Total British exports for June are valued at £29,717,975, and for the six months at £176,934,350.

The Iron and Steel Institute.

The program for the autumn London meeting has been issued. It includes arrangements for visits to the Royal Arsenal, the National Physical Laboratory, Portsmouth Dockyard, and the works of several prominent firms. The Institute is to be congratulated on devoting three days to the reading and discussion of papers, instead of—to use the British parliamentary expression—slaughtering the innocents on the second day. The actual business of the meeting will extend from Tuesday, Sept. 28, to Friday, Oct. 1, inclusive.

Electrolysis and Electric Traction.

The Board of Trade regulations have made it necessary that engineers should give careful attention to the bonding of rails on our electric traction systems, and the stringency of these regulations has resulted in electrolytic disturbances having been brought within very moderate bounds. If the resistance of the return is great the current will find other paths than the rails, such as gas and water mains and lead-sheathed cables—for this is what really occurs when a current is said to return through earth—and will set up corrosion of the surfaces of such metallic conductors. The rate of corrosion depends on the quantity of stray current; but that serious mischief has been caused in this way is unfortunately only too well known. If the difference of potential between the extreme of the uninsulated return and the point nearest to the power station should exceed 7 volts immediate attention to this reduction is requisite. In a recent issue the *Engineer* calls attention to the troubles which have arisen at Winnipeg in consequence of no such salutary rules as those enforced by our Board of Trade having been observed, and deals with the report of Prof. L. A. Herdt upon the electrical conditions existing in the city, particularly in connection with the return circuit of the Winnipeg Electric Railway Company's system and its connection with the Government telephone cable system. This recently issued report shows how much serious damage can be done to water and gas mains in conse-

quence of leakage from badly bonded rails and high-resistance return circuit. The report of the city electrician shows that in six districts there can be no doubt as to holes and breaks in water pipes and lead-sheathed cables having been caused by electrolysis; and that in four districts this is due to the bad condition of the bonding. Professor Herdt recommends that the practice of bonding the tracks to water and gas mains should be abandoned, because, whilst affording local protection, it has undoubtedly encouraged leakage currents and intensified electrolysis troubles. The article concludes by approving Professor Herdt's recommendation of the erection of a sub-station with the view of reducing the return current through the rails in the center of the city and his insistance on good rail-bonding.

Market Report for August, 1909.

Scotch pig rose slightly to steady at 56/s. since moving more sharply to meet present revival, to 58/3, present 57/3.

Hematite jerked on the 4th sixpence, afterwards rose from 50/4 to 57/4 on the 17th, afterwards unsteady to firmer at 58/.

Antimony, black sulphide powder, per ton	£22. 0. 0
Sulph. of ammonia, f.o.b. Liverpool, per ton	11.10. 0
Copper sulphate, per ton	18.15. 0
Caustic soda, white, 77 per cent	11. 2. 6
Bleaching powder, 35 per cent	4. 5. 0
Shellac, standard T. N. orange spots, per cwt	3.16. 0
Carbolic acid liquid, 97 to 99 per cent., per gal	11
Creosote, ord. good liquid, per gal	2½
Naptha solvent, 90 per cent., 160° C., per gal	10
Rubber, Para fine, per lb	8s. 3d.

Tin is decidedly stronger than at the beginning of the month. Commencing (on the 3d) at £133.3.4, it fell on the 6th to £132.3.4, then rose to £136 on the 16th, closing at £135 to £137 (28th).

Copper rose slightly to the 10th, being low at £57.15.0; continued to rise to £60.5.0, and has since fluctuated between £58 and £60, present price £59.7.6.

Eng. Lead steady, about £12.15.0.

Iron, Cleveland warrants inclined to rise since the 5th from 49/10 to 50/4 on the 17th; present price 50/11 (27th) brisk.

London, August, 1909

RECENT METALLURGICAL AND ELECTROCHEMICAL PATENTS

Iron and Steel.

Electric Steel Refining.—The U. S. Steel Corporation, by adopting last year the Héroult furnace for their South Chicago and Worcester plans, has become the pioneer of the large electric steel furnace in this country. Evidence of the quiet way in which the Steel Corporation has been interested for a longer period in electric steel refining, is found in a recent patent of William R. Walker (application filed April 20, 1906). It relates to a combination of converter and electric furnace. He treats molten pig iron in an acid-lined Bessemer converter in the ordinary way until it has been substantially desiliconized and until the carbon has been removed or to somewhat above the limits ordinarily obtained in the use of the Bessemer converter, enough carbon being left remaining (preferably from 0.04 per cent to 0.3 per cent or thereabout) to prevent an oxidized condition of the metal and to enable the metal to remain sufficiently fluid to permit its ready transfer from the converter. He then takes this desiliconized and nearly decarbonized metal and—either directly or through an intermediate mixer—introduces it into an electrical furnace, with a basic lining, adding iron oxide together with burnt lime. The reaction caused by the basic additions, together with the continued heating is to dephosphorize and desulphurize the metal, the phosphorus passing into and becoming combined with the resulting slag. Mr. Walker says: "This process enables me to improve the product of the Bessemer converter in such manner as to obtain steel of the quality produced from the open-hearth furnace or by the crucible process, and enables me to employ for the Bessemer converter iron containing more phosphorus than is permissible in so-called Bessemer iron, for the acid Bessemer process does not remove phosphorus, and any phosphorus contained in the pig iron charged into the converter will appear in the resulting steel." In his combination process Mr. Walker thus aims at the same ends as the Héroult process, but the combination is somewhat different, since in the original Héroult process the treatment is carried further than is proposed by Walker. Héroult removed the phosphorus in the converter, but thereby overoxidized his metal, so that his electric furnace treatment involved deoxidation, desulphurization, and recarburization. However, there have recently been some very interesting developments in the removal of phosphorus in the electric furnace, though it is still too early to report them. (934,247, Sept. 14, 1909.)

Induction Furnace.—In the electric induction furnace the magnetic leakage fluxes around the primary coil and around the secondary melting channel exert a considerable influence on the working conditions (power factor, efficiency) of the furnace. The object of a patent of Otto Frick is to suppress, to a considerable extent, this leakage flux, especially around the primary coil. For this purpose he places "around the field core a short-circuited conductor having two coils placed at a distance from each other and wound in opposite directions, each coil consisting generally of only one winding, and connected in such a manner as not to be effectively induced by the main field, whereas the lines of force of the leakage field or fields pass through the closed circuit of the conductor, and excite therein a current counteracting the said field." Such short-circuited conductors are termed leakage-field coils. Fig. 1 shows one form of the arrangement, the lower diagram being a plan view of the short-circuited conductor; 2 is the usual annular melting channel, 3 the primary coil surrounding the transformer core 4, while 5 and 6 represent the limits of the primary and secondary leakage fields, respectively. To neutralize the leakage field from the primary coil, a short-circuited conductor or loop is provided, consisting of a central part 7, right below the primary coil, and an outer part 8, whose diameter is so large that it substantially incloses the leakage field of the primary coil and which is so arranged that the current in the same will run in opposite direction to that in the part 7. The main field in the closed iron core exerts the same inducing action in the parts 7 and 8 of the short-circuit loop or conductor 7, 8, and inasmuch as these parts are connected in series so that the induced currents will flow in opposite directions, the result of this induction will be zero. The leakage field of the primary coil flowing between the parts 7 and 8 excites in the

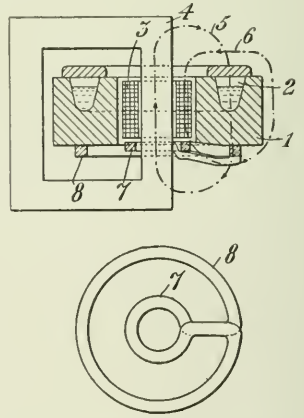

FIG. 1.—FRICK INDUCTION FURNACE.

short-circuit conductor a current counteracting the leakage field. As indicated in the drawing, also a part of the leakage field of the secondary conductor passes through the space between the loops 7 and 8 formed by the short-circuit conductor, and inasmuch as this field has the same direction as the primary one, also this leakage field is partly counteracted by the current produced in the short-circuit conductor. Various modifications of the arrangement are shown. (933,169, Sept. 7, 1909.)

Refining Steel or Other Metals.—To produce special steels, etc., L. Hippolyte Baraduc-Muller places bricks or blocks containing the elements to be embodied on the molten steel or metal bath. The bricks are formed of oxides of nickel, chromium, manganese (or whatever metal is desired to be added) and siloxican or silicon carbide (carborundum) or carbo-silicon Si_2C; the following are three examples of composition of these bricks:

1. Oxycarbide of silicon (siloxicon)	0.270
Oxide of nickel	1.225
Lime	0.056
Magnesia	0.040
Sodium carbonate	0.106
	1.697
2. Carborundum amorphous or crystalline	0.400
Green oxide of chromium	0.760
Lime	0.056
Magnesia	0.040
Sodium carbonate	0.106
	1.362
3. Carborundum amorphous or crystalline	0.400
Manganese dioxide	1.740
Lime	0.056
Magnesia	0.040
Sodium carbonate	0.106
	2.342

These bricks have a density from 2.05 to 2.65, while that of the metallic bath is from 7.1 to 8.9, so that the bricks float on the bath and soon assume a high temperature, causing the siloxicon or carborundum or carbo-silicon to react on the metallic oxides and produce the desired metal, alloy or silicide. The latter, having a higher density than the brick, sinks down into the bath, which is being stirred to facilitate dessimination. The bricks are consumed gradually in a relatively short time.

The bricks are made as follows: The ingredients are ground to a fine powder, and when a peroxide of a metal is involved a proportional quantity of powdered coal is added, then 10 per cent to 25 per cent of clay or clay-marl melting at about 1220° C. is added. When the mixture is homogeneous 5 per cent to 10 per cent of water is added, containing one-quarter to one-half of its weight, according to the case, of neutral silicate of soda at 42° Baume. The mixture being moistened in a homogeneous manner, is granulated while fresh through a sieve having large meshes and formed in molds into bricks under a pressure of about 350 kg per square centimeter. When the bricks are taken out of the mold, they are dried in the open air or by artificial heat. The bricks when dried are sufficiently resisting and hard to be handled and transported without breaking. To make them extremely hard they may be baked like building bricks to a temperature of 1000° C. at the most. The bricks may be agglomerated with magnesia and magnesium chloride in solution, or with a small quantity of cement or like material. The bricks thus worked bear very well all variations of sudden changes in temperature. It is claimed that the reactions between the metallic oxides and the siloxicon or carborundum, etc., yield nearly theoretical results, so that alloys or steels of definite composition are produced in one operation, without a separate production of the metal, alloy or silicide in a special smelting operation. (933,357, Sept. 7, 1909.)

Calcium Silicide.—Calcium silicide has been found to be an excellent refining agent for metals (especially steel) on account of its desulphurizing, dephosphorizing and deoxidizing properties. A new and very simple process of manufacturing it is patented by T. L. Willson and M. M. Haff. A metallic carbide of an alkaline earth, such as calcium carbide, is mixed with silica and enough free carbon added to satisfy the oxygen of the silica. Satisfactory proportions for the mixture are as follows: calcium carbide 64 parts, silica 120 parts, carbon 24 parts. In subjecting this mixture to the heat of an electric furnace, calcium silicide, probably of the formula $CaSi_2$, is formed, according to the equation

$$CaC_2 + 2\,SiO_2 + 2\,C = CaSi_2 + 4\,CO.$$

Instead of calcium silicide another carbide like barium carbide may be used. (934,379, Sept. 14, 1909.)

Graphite Rock as Reducing Agent.—For the reduction of iron ore in the electric furnace, K. A. F. Hiorth proposes to use natural graphite rock as reducing agent. Natural graphite rock (not pure graphite) contains, in addition to silica, minerals of a basic nature which act as a flux. Graphite rock containing silica is found in large quantities, but is valueless for lead-pencil or crucible material and, therefore, forms at present no valuable raw material, the refining of which would be remunerative. Another advantage is that this graphite rock can be had substantially free from sulphur and phosphorus. In this way it is possible to produce a very pure iron directly from the ore in the electric furnace. (934,170, Sept. 14, 1909.)

Galvanizing.—A new electrolyte for producing hard and smooth deposits of zinc on iron and steel, is patented by Mr Abraham Van Winkle (Hanson & Van Winkle Company, of Newark). The electrolyte is a solution containing fluosilicate of zinc, in combination with salts of aluminium or other salts of zinc, with an addition of a small quantity of gelatin previously dissolved, or other organic substance, that tends to improve the character of the deposit. This electrolyte remains clear in operation, acts freely on the anode, and permits the use of a solution as strong as 30 per cent Baume. (930,815, Aug. 10, 1909.)

Zinc.

Electric Smelting of Zinc-Lead Ores.—The difficulties of the metallurgy of complex zinc lead ores forming slag are well known. If treated like pure zinc ores in retorts, the slag formed will soon destroy the retorts. If an attempt is made to smelt such ores in a blast furnace the lead is recovered, but the zinc is not recovered but is burnt to zinc oxide, which tends to clog up the furnace. When ores contain relatively small quantities of zinc, with lead and silver, the usual practice is to smelt them in a blast furnace for the lead and silver without recovering the zinc, which to a limited extent can be dissolved in the slag in the form of zinc oxide and can thus be eliminated. Such a treatment is possible with ores containing no more than 10 or 15 per cent zinc. There are, however, large deposits of lead-zinc sulphide ores, containing, for instance, 30 per cent zinc and 10 per cent lead, which have heretofore been commercially neglected. For the treatment of such ores an electric process of Mr Fred. T. Snyder is specially intended. Mr Snyder is well known to our readers as one of the pioneers of electric zinc smelting.

The ore having first been roasted to convert the sulphides into oxides, is mixed with fluxes such as lime and iron (unless already present) in such proportions as when smelted to produce a slag which will form at a temperature between the volatilization temperatures of zinc and lead (approximately between 1000 and 1100° C., for instance, a slag containing 30 per cent lime, 30 per cent iron oxide and 40 per cent silica). This charge is first preheated in the presence of the carbon to be used in smelting, so as to start the process of reduction as far as possible and drive off the non-metallic gases while keeping the free surface of the charge sufficiently cool to prevent vaporization and loss of zinc at this stage. Finally, after such pre

heating, the ore is smelted upon a slag bath, floated upon a molten lead electrode in a closed electric furnace from which air or other extraneous gas is excluded, the heat being produced by electric current passed through the slag between the molten lead electrode and another electrode (which may be of the same kind) in contact with the slag, the residues being completely fused. The metals are thus reduced, the molten lead sinking to the bottom of the furnace while the zinc is volatilized and escapes from the body of the charge as a gas, which is later condensed. An important consideration is the composition of the charge so that when smelted the slag will form at a temperature between the volatilization temperatures of zinc and of lead, and will possess the characteristics of low specific gravity and high electrical resistance, and will have practically no tendency to dissolve and retain zinc oxide. A slag which is high in lime or other ingredients which has a chemical tendency to displace zinc oxide in the combination will answer these requirements.

The Snyder furnace is shown in Fig. 2. The lower portion of the main chamber *a* of the furnace is divided by a bridge *b*, forming two wells a^1 and a^2, which communicate by U-shaped passages with the exterior of the furnace, as shown in the right-hand diagram. Electric conductors *c* are dipped into the molten metal in the outer arms of these U-shaped passages, the molten metal in said wells a^1 a^2 serving as electrodes connecting with the slag bath of the furnace. There is sufficient material in the furnace so that the slag will rise to a level somewhat higher than the top of the bridge *b*. The two molten electrodes in the wells a^1 a^2 will be electrically united by the body of the slag which lies upon the bridge and floats upon said molten electrodes at either side of said bridge. The maximum heating effect of the current will be developed in the slag at the top, where it is most desired. A layer of carbon is maintained floating on the surface of the slag bath, and is heated thereby to incandescence. As the ore in the furnace is reduced, the elements of the charge go to renew and maintain the electric current; that is to say, the lead as it is reduced adds to the molten electrodes, while the other elements of the charge go to maintain the slag bath and the bed of incandescent carbon floating on its surface.

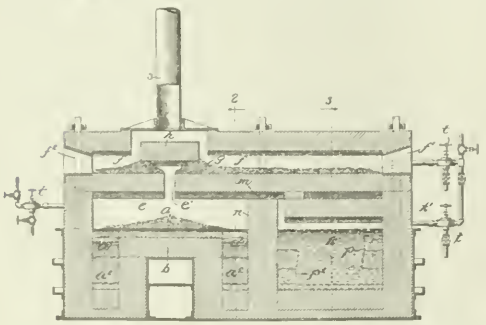

FIG. 2.—ELECTRIC ZINC FURNACE.

The furnace shown is constructed with the preliminary heating or roasting chamber *f* located above the main smelting chamber *a*. An opening e^1 is provided in the reverberatory roof of the smelting chamber through which the roasted ore may be fed into said smelting chamber. Flues *k' k'* lead up through the wall of the furnace and open into the upper roasting chamber *f*, so that the uncondensed gases escaping through said flues may be burned in said last mentioned chamber to assist in the roasting process. A very considerable amount of energy is thus obtained from the carbon monoxide being burned to dioxide. From the roasting chamber the products of combustion finally escape through a stack.

The condensing chamber *k* is shown to communicate with the chamber *a* by the passage *m*. (933,133, Sept. 7, 1909.)

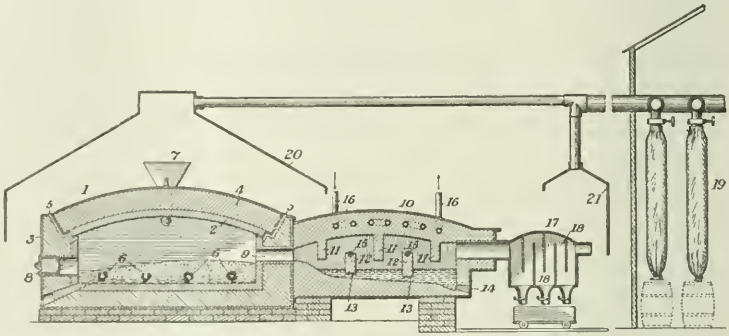

FIG. 3.—ELECTRIC ZINC FURNACE AND CONDENSER.

Condensation of Zinc.—Fig. 3 shows an electric furnace 1 and a condenser 10 for zinc, designed by W. McA. Johnson, who is also a well-known, active pioneer of electric zinc smelting. The charge is introduced through 7 into the electric furnace and the heat is produced by means of the electrodes 6. The reduced zinc vapor escapes through 9 into the condenser 10, where it has to pass along a tortuous path on account of the partitions 11 and 12. In order to recover the zinc vapor in the form of spelter, the temperature of the condensing chamber must be maintained between definite limits, say between 415° and 550° C. For this reason, it may be necessary to heat the condenser during the early stages of operation, while during the later stages it may be necessary to cool it. Mr. Johnson therefore provides both heating and cooling means. The heating means consist of resistance conductors 15. The cooling means are the air conduits 16. Any zinc fumes which may escape from the condenser 10 are recovered in the collector 17. The collecting hood 20 above the furnace and the cooling hood 21 above the collector 17 are connected by a conduit with the usual fan and bags, and used for transporting to the bag house any zinc oxide which may escape. It seems that effective condensation is the main problem of electric zinc smelting. (933,843, Sept. 14, 1909.)

Nickel.

Nickel-Copper Alloys Direct from Matte.—In the manufacture of nickel or nickel-copper alloys the usual bessemerizing process of copper metallurgy cannot be applied, because the oxides and sulphides of nickel do not interact as in the case of oxides and sulphides of copper, so that in the case of nickel it has been the practice to produce matte in the form of sulphides, then to roast the sulphides to bring them to the

state of oxides, then to reduce the oxides with carbon to the conditions of spongy metal and to melt such sponge into the form of ingots. Mr. David H. Browne, of the Canadian Copper Company, has invented a method of producing nickel and copper-nickel alloys directly from the sulphide matte by introducing the molten matte into an electric arc furnace and subjecting it to the action of lime. At the high temperature in the furnace a reaction occurs between the lime and the sulphur contained in the matte so that the lime combines with the sulphur, producing sulphide of calcium and leaving the metal free from sulphur. The reaction which takes place is illustrated by the following formula:

$$3\,CuS + 2\,CaO = 3\,Cu + SO_2 + 2\,CaS.$$
$$3\,NiS + 2\,CaO = 3\,Ni + SO_2 + 2\,CaS.$$

The lime sulphide is lighter than the metal and will float on the surface as a slag. The slag may be thinned by the introduction of common salt, fluorspar, etc. Powdered carbon may also be introduced with the charge in order to reduce the waste of the carbon electrodes. In treating matte containing 22 per cent of copper, 58 per cent of nickel, 0.5 per cent of iron, and 28 per cent of sulphur, Mr. Browne adds to the charge in the electric furnace an equal weight of lime, and, if desired, powdered carbon to the amount of 5 per cent of the matte. (934,278, Sept. 14.)

Graphite.

Unctuous Graphite.—In converting petroleum coke, etc., into graphite in the electric furnace, the petroleum coke is embedded in an envelope of a mixture of sand and carbon. While the petroleum coke is converted into graphite, the sand and carbon are partly converted into petroleum. But the latter conversion is incomplete and on account of the fragile and non-coherent nature of the carborundum crystals, some of them are liable to become detached and contaminate the outer portions of the graphite. Since a mere trace of the exceedingly hard carborundum will completely destroy the value of graphite as a lubricant, there is a great loss of graphite. This is now avoided by Dr. E. G. Acheson by continuing the operation until the envelope of sand and carbon is completely changed into a coherent and firm mass of carborundum, which can be easily separated from the graphite. For this reason, Acheson continues the heating for 30 or 36 hours or even longer, as distinguished from the 12 or 18 hours in usual practice for graphitization. Further, while formerly a shallow envelope of sand and carbon was employed, Dr. Acheson now uses a deep or thick bed of this mixture; its thickness being at least one-half the diameter of the carboneous parts to be converted into graphite. (933,944, Sept. 14, 1909.)

Nitric Acid from Air.

Fixation of Atmospheric Nitrogen.—I. Moscicki, who has been working for a number of years on a method of fixation of atmospheric nitrogen by means of spark discharges, has now modified his apparatus somewhat along the principles of the Birkeland-Eyde process, but with quite different arrangements. This is shown in vertical and horizontal cross-sections in Fig. 4. Of the two electrodes, *a b*, the one *a* is of cylindrical form but rounded off at the lower end, while the other electrode *b* is formed by a body containing a larger number of passages communicating above and below with hollow cylinders. Both electrodes are arranged for being cooled by means of a liquid, for example, oil, water, etc., a tube *c* which is open at its lower end, extending into the electrode *a* nearly to the point thereof, while in the case of the electrode *b*, there is only a cooling jacket provided with an admission and a discharge pipe. The cooling of the electrode *a* is effected by the admission of the cooling liquid through the tube *c* and the discharge of the same through the pipe *d*. The two electrodes are mutually insulated by means of the sleeve *e*, which is made of good insulating material. The electric energy is supplied through conductors *f* and *g*. The surface of the electrode *b* situated opposite the free end of the electrode *a* is flat and only slightly distant from the former. As shown, the electrode *b* extends entirely across the furnace chamber and forms its lower end wall. The middle portion of the electrode *b* is surrounded by a coil which is intended to produce a powerful magnetic field. The magnetic lines of force of this field are vertical to the flat surface of the electrode *b*.

The gases enter through the pipe *i*, pass the hollow space surrounded by the electrode *b* and force the flame against the surface of the electrode *b*, pass through the flame and go out of the apparatus through the passages in the electrode *b*. The apparatus is specially suitable for working under pressure. The effect of the magnetic field is to make the arc revolve so as to sweep over nearly the whole extent of the plate-shaped electrode. As the electric flame sweeps over the whole upper surface of the electrode *b*, the course from the place of action (that is to say, the flame) to the metallic cooling covered by the products obtained through reaction is exceedingly short, in consequence of which, as the gases are forced violently against the metallic electrode, this cooling of the entire body of the gases takes place momentarily or suddenly after the reaction, that is, after the gas has passed the electric arc or flame, and the quantity of gas serving for the cooling can be considerably reduced. These discharging passages are suitably dimensioned so that the cooling of the gases to 700° C., or the temperature at which the gases produced will not decompose, is possible. Assuming that all conditions and dimensions are suitable, only ½ cubic meter of gas will be required per kw-hour flame energy (while it is claimed for the ordinary flame arrangement that such a large quantity of gas is needed for cooling as to require not less than 2.5 cubic meters per kw hour). The electrodes are made of copper. (933,084, Sept. 7, 1909. Another patent of the same inventor is No. 930,212, of Aug. 3, 1909).

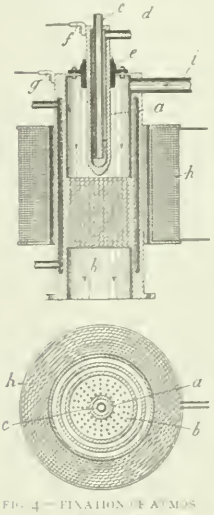

Fig. 4.—Fixation of Atmospheric Nitrogen.

Nitric Acid from Air.—The new process of the Badische Company was described in detail and illustrated in our June issue, page 245. We therefore notice here simply, without further discussion, the fundamental patent for this process granted to Dr. O. Schönherr and J. Hesselberger. Some of the claims are quite broad. For instance, the first one, relating to "the process of producing a long stable electric discharge which consists in directing the discharge from one terminal along side another by means of a current of fluid," or the 7th claim referring to "the process of maintaining a long electric arc which consists in maintaining an enveloping current of fluid as a shield against lateral escape." (930,238, Aug. 3, 1909.)

Sulphuric Acid.

Electrolytic Process for Oxidation of Sulphurous Acid.—A patent of G. C. de Bruyne refers to a process of manufacture, concentration and purification of sulphuric acid, in which the sulphuric acid is produced by direct oxidation of sulphurous acid by "nascent oxygen" obtained by an electrolytic decomposition of water. "The sulphurous acid enters by the positive electrode and is scrubbed in the water (which is decomposed under the action of the current) until the oxygen is released, which acts in a nascent condition." The hydrogen is separately collected. As shown in Fig. 5, the apparatus con-

sists of an external earthenware vessel *A*, capable of supporting a certain pressure. A second cylindrical vessel *B* of porous porcelain is inserted axially in the vessel *A*. A platinum wire *C* placed in the axis of the vessel *B* serves for connection to the positive pole. In the vessel *A*, a mixture in suitable proportions of granules of retort carbon or coke and antimonial lead, is packed all around the vessel *B*. An antinomial lead rod *D* passes through the mass of these granules and serves as connection to the negative pole. A tight-fitting earthenware lid or cover *E* hermetically closes the vessels *A* and *B*, with the aid of a mastic, which resists the action of concentrated sulphuric acid. The two rods *C* and *D* pass through tight joints.

A suitably proportioned mixture of liquefied sulphurous acid, supplied directly from the furnaces and compressed to the

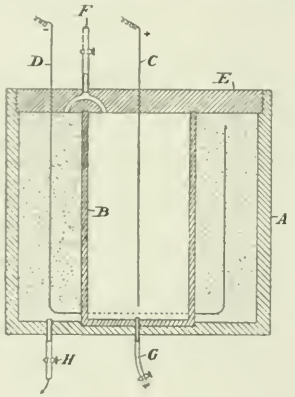

FIG. 5.—ELECTROLYTIC CELL FOR SULPHURIC ACID.

desired degree, and of sulphuric acid at 45° Baume—that is to say, having a sufficient quantity of water to give it the same density as the liquid sulphurous acid, is introduced into the two vessels *A* and *B*, by a pipe *F*, which passes through a hermetically closed joint in the cover or lid *E*. Of course, the pressure must be maintained at the necessary minimum. "The water thus introduced into the apparatus has for its object to insure the conductivity of the mixture necessary for the electrolysis, at the same time it is itself decomposed, furnishing at the anode the nascent oxygen, which oxidizes the sulphurous acid and converts it into sulphuric acid around the platinum wire *C*." At the same time, if the current is of a suitable intensity, very fine and pure sulphur is deposited in proximity to the negative electrode *D*, by the action of the sulfhydric acid due to the reduction of a portion of the sulphurous acid by the nascent hydrogen. The size and especially the distance apart of the walls and vessels *A* and *B* must be small, and the current of sulphurous acid sufficiently rapid. A tube *G* for discharging the sulphuric acid connects with the lower part of the vessel *B*. In the vessel *A* around the carbon and antimonial lead granules, and around the rod *D*, the solution of ordinary sulphuric acid mixed with the liquid sulphurous acid is renewed simultaneously with the latter.

At the end of a certain time, when the precipitated sulphur has accumulated in the vessel *A* and the vessel *B* is filled with concentrated sulphuric acid, the inflow of sulphurous acid at *F* is stopped, and the pressure is suspended, and the sulphurous acid which expands and vaporizes is collected in a gas generator. A part of the concentrated sulphuric acid is withdrawn at *G*, and at *H* the semi-liquid sulphur, while water which assists this latter operation is introduced at *F*. The sulphur is separated by decantation and then the vessel is set going again as before. Instead of sulphur other by-products may be obtained according to fluctuations of commercial requirements. Thus, by lowering the sulphurous and sulphuric acid contents in the initial solution to be electrolyzed, the voltage may be lowered and the hydrogen will be released at the cathode without combining. (928,844, June 20, 1909.)

Manufacture of Sulphuric Acid.—While, besides its applications in medicine, radio-activity has so far been chiefly of scientific interest, Mr. W. Hallock wants to employ it to an intensely practical problem of chemical engineering, the change of SO_2 to SO_3, without any catalytic agent and without elaborate apparatus. His process comprises "the oxidation of the sulphurous oxide by means of the ionization of one or more of the gases evolved by radium, uranium or other radio-active substance or by X-rays, cathode rays, Lenard rays or ultra-violet light, or other ionizing substance or agency." He has found that "a comparatively feeble agent serves to bring about the oxidation of sulphurous oxide if oxygen is present, and the ionizing influences serve to accomplish this result—that is, to put the atmosphere in such a condition as to precipitate the acid." (930,471, Aug. 10, 1909.)

Caustic Soda and Chlorine.

Iron Oxide Electrode.—In the plants using the Griesheim "elektron" diaphragm process for the electrolytic production of caustic soda and chlorine, iron oxide anodes have been employed for a few years. Their advantage over carbon anodes is that the chlorine gas produced will not be mixed with carbon dioxide. These iron oxide electrodes are made from molten Fe_3O_4 or molten Fe_2O_3. When Fe_2O_3 is melted, oxygen escapes and Fe_3O_4, together with a small proportion of FeO, are formed. The presence of this FeO is objectionable for two reasons; first, it causes cracking of the electrodes when cooling; second, the electrodes will not resist chlorine. It is, therefore, important in the manufacture of electrodes to eliminate the FeO. For this purpose H. Specketer adds to the molten mixture a small quantity of unmelted, finely pulverized Fe_2O_3 which unites with the FeO to form Fe_3O_4, instead of Fe_2O_3. He may also add Cr_2O_3 or Mn_2O_3. The homogeneous crystallizing melt thus produced is poured into molds, closed at the bottom. The mass solidifies gradually from the outside so that a rigid layer is first formed on the exterior, which layer gradually increases in thickness toward the center of the mass. When such layer has reached the desired thickness, the remainder of the fluid contents of the mold is returned to the melting vessel to be used for a new charge. The mold is then opened and the electrode, which is closed at its lower end, is removed and allowed to cool slowly. (931,513, Aug. 17, 1909.)

Magnesia.

Magnesium.—At present magnesium is produced electrotytically from an electrolyte of fused magnesium chloride, with potassium chloride added as a flux, the separated magnesium being collected at the bottom of the vessel. It is only under certain conditions of temperature that such an electrolyte is lighter than the separated magnesium, and it is difficult to so manage the process that these temperature conditions are maintained so that a good separation of the magnesium results. G. O. Seward and F. von Kügelgen (Virginia Laboratory Company) accomplish the separation of the produced magnesium from an electrolyte, by using a heavier electrolyte, by the addition of one of the salts of the alkali earth metals. For instance, in the process above mentioned, they replace the potassium chloride partly by barium chloride, using, for instance, an electrolyte containing 5 parts of magnesium chloride, 5 parts of potassium chloride, 3.5 parts of barium chloride. In this electrolyte the produced magnesium rises readily to the top, where it is collected. (931,392, Aug. 17, 1909.)

Anti-Friction Alloy.—An anti-friction bearing alloy of lead, cadmium and magnesium is patented by E. A. Touceda. The magnesium is intended to harden and toughen both the lead and cadmium constituents. The alloy contains from one-tenth of 1 per cent to 5 per cent of magnesium, about 10 per cent of cadmium, and the remainder lead. (933,139, Sept, 7, 1909.)

Chromium and Other Refractory Metals.

Boron as Reducing Agent.—Mr. Frederick M. Becket, metallurgist of the Electro Metallurgical Company, proposes the use of borides of the alkali earth metals; for instance, calcium boride or carbon boride for the reduction of the oxide ores of chromium, tungsten, molybdenum, etc. Chromite may be directly reduced in this way (930,028, Aug. 3, 1909.) In another patent by the same inventor, he proposes the use of boron-silicon alloys as reducing agent. Metallic chromium, for instance, may be produced in this way, directly from chromite The operation is facilitated by the presence in the charge of a base capable of uniting with the oxide of boron produced. Most commercial chromites contain 8 to 15 per cent of alumina and a similar proportion of magnesia, and to the extent of their presence these serve the purpose of a basic flux. In case of ores free from basic constituents, or in case of the deficiency of such constituents, a suitable basic flux, as lime, is added as required. The slags are advantageously utilized for the production of borates, as, for example, the borates of the alkali metals, or they may be reduced by carbon in a separate operation. In the latter case, the boron constituent is recovered, usually in the form of an alloy with the other reducible constituents of the slag, as, for example, an alloy of boron with silicon, or with silicon and calcium, often in conjunction with a considerable proportion of the metal, as chromium, etc., originally reduced. In this form the boron may be repeatedly utilized for the reduction. (930,027, Aug. 3, 1909.)

Magnetic Concentration.

Roasting Furnace.—In obtaining a roast to be followed by magnetic separation, it is absolutely essential to prevent the ore particles from clinging together by reason of too much heat resulting in semi or partial fusion. As has been repeatedly noticed in this journal, Mr. Arthur R. Wilfley, of Denver, Col., avoids this difficulty by causing the ore to drop downwardly through a flue or chamber. At the bottom of this flue a water jacket or other cooling medium is arranged which the ore engages as it falls, thus suddenly cooling it before its particles are allowed to come in contact under such circumstances as to permit them to cling together. In a recent patent he refers to a difficulty due to the fact that the ignition of the impurities, such as sulphur, produces heat, and the ore has, therefore, a tendency to rise in temperature as it moves downward. There is, therefore, some danger that before reaching the bottom of the flue or chamber it may become heated to such a degree that there will be a strong tendency for the particles to cling together as they come in contact This difficulty Mr Wilfley now overcomes by the introduction of cold air at the bottom of the ore flue or chamber, which is carried upwardly in conduits, whereby it is separated from the ore and, therefore, does not interfere with the downward movement of the ore or with the draft of the furnace. As this air travels upwardly through the pipes, within the ore flue or chamber, its temperature rises, and by the time it reaches the top of the flue and escapes from the air pipes or conduits, it is exceedingly hot and comes in contact with the falling ore. By reason of this construction and arrangement the ore as it moves downward is subjected to the action or influence of the air within the pipes, which gradually becomes colder as the ore approaches the lower extremity of its flue or chamber. In this way the ore is partially cooled as it passes downwardly in the flue and the tendency to become overheated is neutralized. At the same time, by the introduction of the air through the pipes into the ore in the upper part of the flue, it becomes practicable to roast a heavy sulphide ore, without additional fuel, after the original firing of the furnace or the commencement of the roasting operation (930,254, Aug. 3, 1909.)

Aluminium.

Aluminium Solder.—For soldering aluminium or for closing openings and cracks in aluminium articles, Z Tamassy patents a solder consisting of 130 grams of antimony, 2 lb. of zinc spelter, ½ lb. of pure tin and 44 grams of salicylic acid (powder) (931,523, Aug 17, 1909.)

Aluminium Solder.—J. F. Guggenbuhl patents an aluminium solder which is claimed to be particularly adapted for securing together aluminium parts into solid articles such as have heretofore been made by crimping or clasping the parts together. The solder consists of 85 per cent zinc, 10.7 copper, and 4.3 aluminium. It is applied with the aid of a blowpipe. (933,433, Sept. 7, 1909.)

SYNOPSIS OF PERIODICAL LITERATURE

Iron and Steel.

Influence of Temperature on Mechanical Properties.—Prof. M. Rudeloff, of the German Imperial Testing Laboratory, reported upon his carefully made experiments to the recent Congress of the Society for Testing Materials at Copenhagen. He heated the specimen by steam, naphthaline vapor or naphthyamine vapor in a specially constructed vapor bath attached to the testing machine. For the attainment of comparable results, uniform rapidity of applying the load is necessary. Temperatures were determined by thermo-electric couples, pressed against the sample itself. *Wrought iron* decreases in elongation up to 150° C., and increases in tensile strength up to 250° The figures are:

	Tensile Strength		Elongation.
C	Kg per sq. mm	Lbs. per sq. in	Per cent
20	34.5	49,300	30.5
50	36.0	51,400	25.5
100	38.0	54,300	16.0
150	42.5	60,700	14.0
200	47.0	67,100	17.5
250	49.5	70,700	23.0
300	48.0	68,600	30.0
350	40.0	57,100	35.0
400	32.3	46,100	40.0

The results in general confirm those of Kunt Styffe, published in 1863. *Soft Bessemer* steel showed tensile strength decreasing to 50° C., then increasing to a maximum far above its ordinary strength, at about 250°, and thereafter a rapid decrease; the elastic limit, on the contrary, falls steadily with increase of temperature; the elongation before rupture falls rapidly and considerably as temperature rises to about 150°, then rapidly increases. This behavior of elongation and ultimate tensile strength explains the "blue-shortness" of steel first pointed out by Valton in 1877, as noted in bending tests at various temperatures. *Soft open-hearth steel*, with low carbon (0.20 per cent), behaves similarly to the former, reaching its maximum strength at 200° to 300° and minimum elongation at 200°. Rudeloff's results are as follows:

	Tensile Strength		Elongation.
C.	Kg per sq. mm	Lbs. per sq in	Per cent
20	43.5	62,100	24.0
50	44.0	62,900	22.0
100	45.0	64,300	18.0
150	46.0	65,700	14.0
200	46.5	66,400	11.0
250	46.0	65,700	12.0
300	44.3	63,300	13.0
350	43.0	61,400	14.0
400	42.0	60,000	15.0
450	37.0	52,900	17.0
500	31.0	44,300	19.0
550	25.0	34,300	21.0
600	20.0	28,600	23.0

Cast iron retains its strength practically unimpaired to 400° C., but loses 30 per cent at 500° and 60 per cent at 600°. The specimen tested was a gray foundry iron containing 0.52 per

cent phosphorus. The hardness is nearly constant to 300° and then falls very rapidly. Malleabelized cast iron shows a slight increase of tensile strength to 275°, and then a rapid falling off; the elongation is practically constant to 400°-450° and then rises. A summary of the literature of the subject accompanies the article.

On a Uniform Nomenclature.—A committee of the International Society for Testing Materials made its second report on this subject at the recent International Congress of that society in Copenhagen. The committee is large to unwieldiness, and of the 20 members 6 are from Russia alone, while such an historically and commercially important iron-producing country as Sweden is not represented. Under such circumstances, a report of a high order, which might possibly have been acceptable to the scientific and commercial world, was not to have been expected—and has not been produced.

The report contains a glossary of terms, in English, German, French, Italian, Spanish, Swedish, Danish and Dutch. (The Hungarian members of the society have requested that Hungarian be added to the report as published.) The glossary is fairly complete. There is, further, a table of definitions in English which is intended to make precise the significance of the English terms. There is also an abridged statement of the present status of the metallography of iron and steel, with some suggested new terms.

In the field of definitions, *pig iron* is defined as "cast iron which has been cast into pigs direct from the blast furnace." This does not correspond to the facts; it should be rather "cast iron as produced by the reduction of iron ore or similar raw material." This latter definition would include melted pig iron which has *not* been cast into pigs, and also cast iron produced in an electric reduction furnace or in any other way—which materials are excluded from the committee's definition, but included in commercial usage. The use of the term "steel cast" as an adjective to apply to a steel casting which has been neither forged nor rolled is a phenomenon evolved, we fear, from the inner consciousness of the committee and really unknown to commerce or practice. "Steel" is carefully though somewhat awkwardly defined. We regret to see that such materials as electric (furnace) pig iron, electric (furnace) steel, open-hearth electric steel, Bessemer electric steel, and ferro-alloys are either unknown to the committee or else the terms used to designate them in commerce are considered beneath their consideration.

In the matter of the microscopical constituents (real and hypothetical) of iron and steel, the chief innovation is the proposition to use "metaral" as the equivalent of the longer term "microscopical constituents." It is pointed out that the longer term is inaccurate when applied to such "macroscopical" objects as the graphite in pig iron, and that "metaral" as applied to these would be the analogue of "mineral" as found in rocks. The analogy is faulty; minerals are chemical entities, and physical admixtures of minerals from rocks. While ferrite would be analogous to a mineral, pearlite would be analogous to a rock. It seems to us that the question is to distinguish by some term the ultimate chemical constituents of iron such as are given by a *chemical* analysis from the proximate *physical* constituents, such as can be separated or distinguished physically from each other. Would not the term "physical constituents," instead of "microscopical constituents," solve the difficulty? We commend it to the attention of metallographists and all interested in the subject.

Slag Enclosures in Steel.—Walter Rosenhain, of the British National Laboratory, read a paper at the Copenhagen Congress of the International Society for Testing Materials upon this important topic. He is convinced that sufficient attention has not been devoted to the harmful influence of these "physical constituents" of steel, and supports his thesis by photomicrographs of steels which have actually failed in use, all of which show the slag enclosures referred to. They are best found by examining a section taken parallel to the direction of rolling or of extension, if the steel has been rolled or forged. By highly polishing, the enclosures in the steel appear either as "dove gray" sulphide of manganese or as minute black patches, which are either slag or the cavities from which the brittle particles of slag have been torn during the polishing process. These latter are either silicate of manganese or oxides or silicates of iron. In a rail which failed in service the slag enclosures were large and numerous. The manganese sulphide is best recognized by applying to the steel a sheet of photographic silver bromide paper moistened with dilute sulphuric acid, as suggested by Baumann, thus obtaining a "sulphur print."

The remedy for the manganese sulphide enclosures is evidently to keep the molten metal at rest for a sufficient time after the addition of manganese to allow the sulphide to rise into the slag. This takes considerable time, so much as to be difficult to apply in practice. The contamination with oxides is probably due to oxidation during teeming, while silicates can be readily formed by the incorporation of particles of silica from the refractory materials of the runners and molds; some may also be left in the steel as a sort of emulsion after the violent stirring together of slag and metal which occurs in the Bessemer process. Altogether, the quiet standing of the molten metal a considerable time before teeming, its protection from oxidation as far as possible during pouring, and the avoidance of loose or easily detached siliceous material in runners or molds, may go far to diminish the harmful effects which are undoubtedly caused by these slag enclosures.

Copper.

Copper Leaching.—*Metallurgie* of Aug. 8 contains a note by W. Borchers on a copper plant in Southern Tyrol, in which an attempt had been made to employ the old electrolytic process of Siemens, the first stage of which is leaching with ferric sulphate solution. In practice even this preliminary leaching process was a failure, so that the subsequent electrolytic precipitation of the copper was never attempted. The reason was that the ore contained the copper in form of the compound $Cu_2S.FeS.FeS_2$; this was roasted at such a high temperature that the copper oxide combined with other oxides and formed compounds like $CuO\ Fe_2O_3$ and silicates. These are not amenable to leaching. Simple copper compounds can easily be leached; but when the copper compounds are combined with other sulphides or oxides, the attack of the ferric sulphate solution becomes a very slow reaction. An investigation of Dr. Thomas showed that roasting of the ore at a very low temperature (450° C. to 500° C.) yielded a product containing the copper partly as sulphate, partly as oxide, and partly as copper sulphide, free from FeS. The product of such a roasting process can easily be treated by leaching. For this reason, after the failure of the Siemens process, it was decided to work the copper ore simply for copper sulphate, for which there is a good market among the wine growers of Southern Tyrol. But as the copper deposit has since been found to be much larger than had been supposed at first, it is now proposed to work the ore either for copper matte or metallic copper. Professor Borchers thinks that for this ore concentration by the Elmore flotation process and subsequent smelting in the electric furnace would be particularly suitable. Experiments in this direction have been carried out at the Institute of Technology in Aachen and "the electric smelting experiments have gone so far that a decision will be possible within a short time." The local conditions for electric smelting are especially favorable, since a water-power of at least 3000 hp could be utilized, its development being possible with relatively low expense If this decision should be reached, this would be the first commercial electric copper smelting plant.

Railroads and Metallurgy.—Bulletin 58 of the Institution of Mining and Metallurgy contains an advance copy of Dr. J. Douglas' paper on the influence of the railroads of the United States and Canada on the mineral industry.

A New Development in Continuous Annealing and Hardening Furnaces.

The Rockwell Furnace Company, 26 Cortlandt Street, New York, have recently improved their well-known type of internally-fired rotary furnace, which gives a greater flexibility in range of work handled by it, and greatly adds to its durability. Gas or oil fuel may be used.

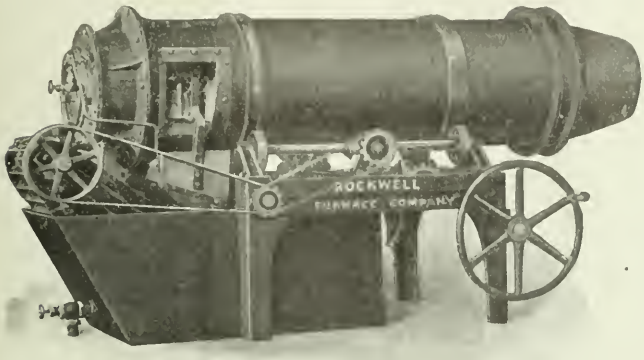

FIG. 1.—ADJUSTABLE AUTOMATIC ANNEALING AND HARDENING FURNACE.

Heretofore these furnaces were built only with special lining brick which formed deep helical channels with separating spiral walls for feeding the material forward. This arrangement worked very well for light smooth pieces, such as lock washers, balls, etc., and is still spirally lined for this class of work, but was found to be unsuitable for long pieces, such as bolts, rivets, etc., and irregular shaped steel punchings, forgings, castings, etc., and other methods of feeding the material through the furnace were required.

In the present type of furnace, for smooth or round work, the rotating cylinder or drum is lined with a standard refractory hard brick, with a smooth internal surface The furnace is mounted in such a manner that its axis may be tilted at an angle giving the revolving hearth an incline with the discharge end lower than the entrance or feed end. The gradual incline causes the material to feed forward, and by means of a hand-wheel the degree of pitch may be adjusted so as to regulate the progression of the material through the furnace, and consequently the time of heating.

The advantages of this method of automatic continuous heating are many. The material is charged in a hopper in bulk at the exhaust end of the furnace and fed automatically into the chamber, the material comes continually in contact with the newly heated surface of the chamber, which is revolving, thereby absorbing the heat from the lining as well as from the heated gases.

In a stationary furnace the heat from the sides and roof are not utilized, as the material remains in a fixed position; that farthest removed from the heat requires a much longer period to be brought to the desired temperature and the more exposed pieces are liable to overheating, while others insufficiently heated, and a much longer time required.

Tests of material being heated and hardened in the internally-fired rotary furnace at the rate of 2000 lb. per hour have failed to show the slightest variation. With a pyrometer to insure the proper temperature and the chamber tilted to feed at the proper speed the product must be absolutely uniform.

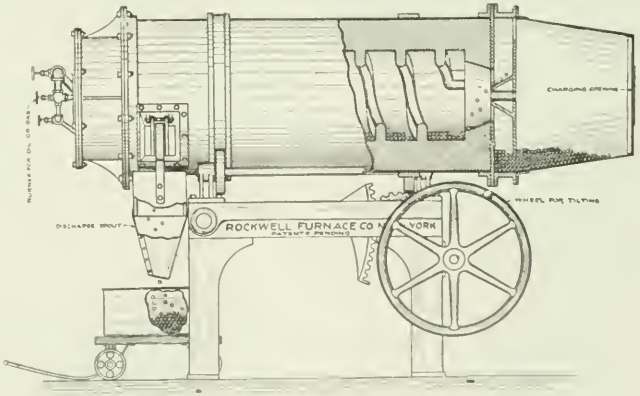

FIG. 3.—ADJUSTABLE INCLINED TYPE WITH HELICAL LINING.

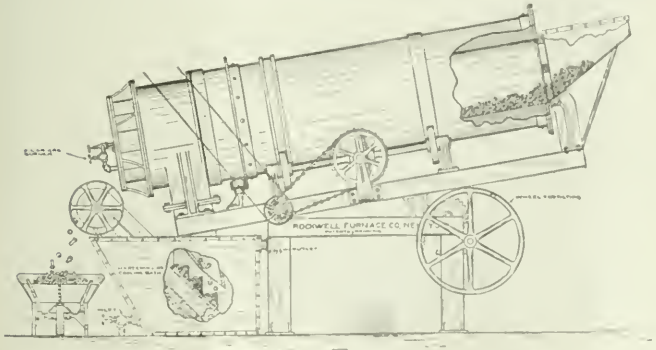

FIG. 2.—ADJUSTABLE INCLINED TYPE WITH PLAIN LINING.

In operation, the pieces are fed continuously into one end of the cylinder. The furnace is fired internally from the opposite end with the zone of highest temperature at the discharge end. The cylinder revolves slowly (1 to 4 r.p.m.) and owing to the slight inclination of the furnace, the pieces treated fall slightly forward at each revolution, gradually progressing toward the discharge end, where they enter a proper receptacle or bath upon reaching the desired temperature.

To prevent oxidation the end of the discharge spout may be carried beneath the level of the bath, thereby sealing it and excluding the air

By this method, clogging or retardation of the work is avoided, as there are no

corners or pockets in which the pieces can lodge. Wear of the lining is reduced to a minimum and does not require renewal until the greater portion of the brick is worn away. In certain classes of work, such as balls, nuts and uniform shapes, the helical or worm type is used, and this furnace may be lined either way, as preferred, but where the smooth lining can be used the cost is less and a greater life in insured.

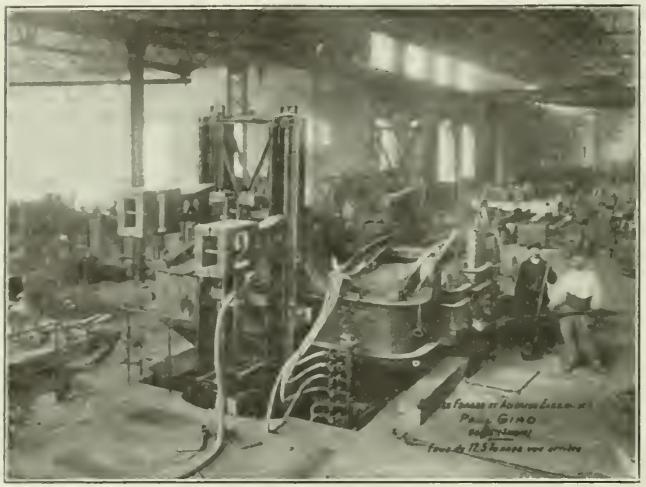

FIG. 1.—PLANT OF CIE. DES FORGES ET ACIERIES ELECTRIQUES, PAUL GIROD, UGINE, SAVOIE, FRANCE. 12½-TON FURNACE IN FRONT

Oil or gas fuel may be used, and perfectly uniform results obtained, as the work treated is heated gradually with every portion of its surface exposed to the direct action of the hot gases and lining, and both temperature and time are maintained constant.

These furnaces are built to suit a wide range of requirements. In the standard sizes at present built for the trade, they are able to handle easily and satisfactorily up to 2000 lb. of stock per hour.

Girod Electric Steel Furnace.

We have repeatedly described the Girod electric steel furnace (see for instance our June issue, page 259, or July issue, page 323), and have also published a sketch of the new Girod steel works in Ugine, Savoie—the largest purely electric steel works in the world (our January issue, page 9). Castings, projectiles, tool steels, structural steel etc., are there manufactured. For this reason, the accompanying three illustrations should be interesting to our readers. We are obliged for them to Messrs. C. W. Leavitt & Co., of New York, the American representatives of Mr. Girod.

Fig. 1 is an interior view of part of the Ugine works of Mr. Girod. A rear view of a 12½-ton Girod furnace is shown in the foreground.

A front view of the same 12½-ton furnace is shown in Fig. 2, while a 2½-ton Girod furnace is shown in Fig. 3.

Aside from these works, there are now 7 other European plants employing the Girod furnace.

Notes.

Steel Testing Machine.—The Landgraf-Turner alternating impact testing machine, made by Messrs. Queen & Company, of Philadelphia, is entering into general use for the testing of steels by impact. Queen & Company have just furnished one of these machines to the Bureau of Standards, Washington, D. C., and have also received an order from the Royal Italian Navy for one to go to Italy by the Italian cruiser now in New York Harbor.

Alundum as Refractory.—Alundum or artificial emery is made from bauxite in the electric furnace of the Norton Company at Niagara Falls. From a recent U. S. Geological Survey bulletin of W. C. Phalen on the production of abrasive materials in 1908 we take the following note on the use of alundum as a refractory, which is one of its more recent applications. Alundum melts at 2300° C. and has a very low coefficient of expansion, if it has any at all. It is, moreover, very inert chemically, and tests made in the basic open-hearth furnaces show that it is not appreciably affected by slags in these processes. The lining of a Deville furnace does not show deterioration after repeated burns at 1800° C. It remains to be proved just how much better alundum is than other standard refractories, as its cost will necessarily be quite high. It is believed, however, that for many special purposes it will prove of great value.

Carbon-Dioxide Recorder.—We have received from the Caldwell Company, 220 Broadway, New York, a pamphlet on the Westover CO_2 recorder. It is in principle similar to the hand analyzers of Hempel, Elliott, and Orsat, but exact mechanism takes the place of the human element. It is, therefore, "a machine and not an instrument." In the series of events, the taking of the sample gas, measuring of it, forcing it into contact with the potash solution, to the measuring of the residual

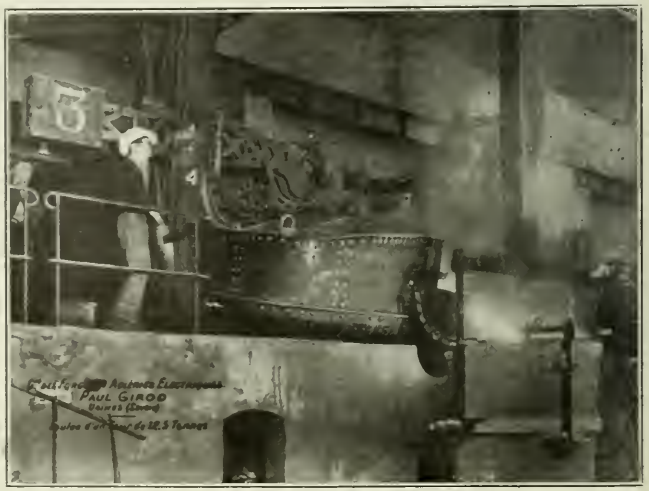

FIG. 2.—12½-TON GIROD ELECTRIC STEEL FURNACE.

part of the charge, all are carried out by tooth gear movements so connected and related that no event can take place out of its proper order or turn. These are operated by a small standard electric motor. The standard recorder is manufactured to make four records. Each record covers a period of 24 hours and the time between each analysis, about 1⅛ minutes, thus making the records or analysis from each boiler about 5½ minutes apart. The electric features of the Westover CO_2 recorder make it easy of adaptation to the Mailloux-Westover damper control, which operates by means of a combination of steam pressure and the rise and fall of the CO_2 gas within the furnace, insuring a step-by-step movement of the damper, adjusted at each step to the exact demands of the moment. The electric features also lend themselves to easy adaptation to the Mailloux-Westover boiler front CO_2 electric signals and to the making of signals

FIG. 3.—2½-TON GIROD ELECTRIC STEEL FURNACE.

or duplicate records at a near or great distance from the boiler plant.

The **Bristol Company**, of Waterbury, Conn., has opened a branch office in Pittsburgh, in the Frick Building Annex. They are now making a specialty of studying the application of Bristol's recording instruments in many different industries. For instance, they have specialized in recording instruments for blast furnaces, including recording pressure gages for hot blast, top gas and steam electric pyrometers for hot-blast temperatures, top-gas temperatures and general tests; electric time recorders for recording the movements of rotary top, skip hoist, large bell, small bell and gage rod, recording thermometers for Gayley dry-blast temperatures, condenser water temperatures, feed-water temperatures, etc.

The **Wheeler Condenser & Engineering Co.**, of Carteret, N. J., at the recent annual meeting of the stockholders, has elected Mr. J. J. Brown vice-president and general manager. Mr. Brown entered the condenser field some 15 years ago as Southwestern manager for the Henry R. Worthington Company and later became their general sales manager. After the formation of the International Steam Pump Company he became their general Western sales manager, with headquarters at Chicago, and resigned that position to take up his present work. The Wheeler Condenser & Engineering Company has recently introduced several important improvements in condensing apparatus, among which are the "dry tube surface condenser," which has shown some remarkable results in high vacuum work. The company has also in hand new and improved types of rotative dry vacuum pumps, centrifugal pumps, centrifugal jet condensers, etc. The plant at Carteret, N. J., is being enlarged and improved. Among these improvements is a new power house which will be equipped with several different systems of condensers for exhibition purposes, as well as for supplying the electrical energy which will be used throughout the shop.

Monel Metal.—With respect to the full article of Mr. D. H. Browne on Monel Metal in our March issue, page 114, it is interesting to note that Monel metal sheets are now manufactured exclusively by the American Sheet & Tin Plate Company, of Pittsburgh. In a pamphlet, recently issued by this company, it is stated that it is "less expensive than nickel or German silver, since in the former the expense is largely in the difficulty of isolating it, and the latter is a manufactured instead of a natural alloy." Monel metal sheets are used for roofing (as in the new Pennsylvania Railroad Terminal in New York) to supplant copper, and owing to their great strength and non-corrosive qualities, a much lighter sheet can be used and greater efficiency and service obtained at a lower initial cost. For this reason Monel metal is also specially suitable for smelter roofs, mine screens, chutes, tanks, kettles, and in general where non-corrosive qualities are important, as well as the toughness of the material to resist impact. Monel metal sheets are made by the American Sheet & Tin Plate Company in sizes up to 36 x 96 and all gauges. These sheets are rolled in the famous Vandergrift works, the largest sheet mill in the world.

High-Speed Tool-Steel Patent Decision.—In our March issue we noticed the outcome of the famous patent suit of the Bethlehem Steel Co. versus the Niles-Bement-Pond Co. for infringement of the Taylor-White patents. This was decided in favor of the defendant and the two Taylor-White patents in question were found invalid by the Circuit Court of the United States for the District of New Jersey. On appeal, the United States Circuit Court of Appeals for the third Circuit has now rendered the following opinion: "The opinion, filed in this case by the learned judge of the court below has so clearly stated the reasons upon which our own determination of this case is founded that further and independent discussion of them on our part is rendered unnecessary. Therefore, adopting the opinion of the court below as the opinion of this court, its decree is hereby affirmed."

Digest of U. S. Patents

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC FURNACES (Continued).

628,782, July 11, 1899, James J. Faulkner, of Memphis, Tennessee.

The material to be smelted, for example a mixture of lime and carbon, is pressed from a hopper, by a fluted roller, between a pair of horizontal rolls, one plain and one grooved, being thereby formed into a series of pencils. Scrapers bear against the lower surfaces of the rolls. Beneath the hopper and rolls is the rectangular furnace chamber, of firebrick, having at one side a long horizontal carbon plate electrode, and in its opposite wall a row of openings, each receiving a carbon rod electrode. The carbon rods are forced longitudinally against the carbon plate by springs. The molded pencils of lime and carbon feed downward from the forming rolls to the electrodes, where they are smelted. The calcium carbide

and unsmelted material pass downward from the smelting zone into a chute having a perforated bottom and screw conveyor, which separate the lumps from the fine material, these being separately discharged. A chimney leads from the smelting chamber.

629,008, July 18, 1899, Oscar Frölich, of Steglitz, Germany, assignor to Siemens & Halske Aktien-Gesellschaft, of Berlin, Germany.

Arc type. A furnace for producing, distilling and condensing metals, e.g., zinc. The furnace chamber is an iron crucible lined with carbon and serving as one electrode. The other electrode is a vertical depending carbon tube. To the upper end of this tube is fixed the condenser, which consists of a vertical cylindrical iron chamber containing a series of horizontal alternate rings and disks, serving as baffles. The gaseous and volatilized products from the arc smelting zone, at the lower end of the tube, pass upward into and through the condenser, the uncondensed gases escaping through a pipe at the top. In use, the charge-mixture is kept at such height, more or less embedding the condensing chamber, as to maintain the desired range of temperature therein; for example, in the case of zinc, a temperature decreasing from 900° C. at its bottom, to 500° C. or less at its top, the temperature in the zone of reduction being specified as 1800° C.

630,283, Aug. 1, 1899, Wilhelm Borchers, of Aix-la-Chapelle, Germany.

Resistance and arc types, especially for the production of calcium carbide. The furnace, or a series of furnaces, are surrounded by or pass vertically through a steam boiler. After the charge has been smelted, the resulting carbide, surrounded by a layer of unreduced material, is left for several hours in the furnace until the heat therein has been utilized for the generation of steam. A series of furnaces, arranged longitudinally in one large boiler, may be worked successively to produce steam continuously. When the furnaces are discharged, the unreduced portion of the charge is so cool that the carbon therein does not burn when exposed to air. The gases escaping from the smelting zone and charge are filtered by passing them through a body of "wood debris," shavings, granulated charcoal, or other vegetable or animal fibrous or porous material capable of retaining dust, and are then collected or fed to a gas engine. The furnace or furnaces have thin metal walls. In the resistance type, horizontal carbon rods pass through the sides, their opposed ends being joined by a resistor of solid or pulverized carbon. The arc type has vertical electrodes, one passing through a hinged base and the other depending within the chamber.

NEW BOOKS.

Ostwald, Wilhelm. The fundamental principles of chemistry. An introduction to all textbooks of chemistry. Authorized translation by Harry W. Morse. 349 pages. Price, $2.25 net. New York: Longmans, Green & Company.

Roth, W. A. Exercises in physical chemistry. Authorized translation by A. T. Cameron. 208 pages, illustrated. Cloth, $2 net. New York: D. Van Nostrand Company.

Mellor, Jos. W. Higher mathematics for students of chemistry and physics, with special reference to practical work. Third edition, enlarged. 662 pages. Cloth, $4.50. New York: Longmans, Green & Company.

Del Mar, W. A. Electric Power Conductors. 330 pages. illustrated. Cloth, $2 net. New York: D. Van Nostrand Company.

White, Marian. The fuels of the household; their origin, composition and uses. 95 pages. Cloth, 75 cents net. Boston: Whitcomb & Barrows.

Franklin, W. Suddards, and Esty, W. Dynamos and motors. 498 pages, illustrated. Cloth. $4 net. New York: Macmillan Company.

Duff, Alexander Wilmer. A textbook of physics. 698 pages, illustrated. Cloth, $2.75 net. Philadelphia: P. Blakiston's Sons & Company.

BOOK REVIEWS.

Theoretische Chemie. By Prof. Dr. Walter Nernst. Sixth edition. 794 pages, 50 illustrations. Price, 20 marks (retail price in New York, $6.50). Stuttgart: F. Enke.

It is a pleasure to note the appearance of the sixth edition of Nernst's excellent and well-known German treatise on theoretical chemistry. In comparison with former editions the work has again been revised and brought up to date. The extensive discussion of Nernst's new thermodynamical theorem is of especial interest.

Steam Power Plant Piping Systems, Their Design, Installation and Maintenance. By Mr. M. L. Morris, M.E. 506 pages, 309 illustrations. Price, $5.00 net. New York: McGraw-Hill Book Company.

In this plentifully illustrated 500-page book, there is presented an abundance of matter of interest and value to the steam engineer and also to the chemical engineer who has to deal with the storage, heating, pumping and chemical treatment of liquids and gases.

As the author asserts, it is not a compilation of tables and data, and neither is it a mathematical treatise on the flow of gases, the coefficient of friction of fluids or of the properties of structural materials. The author gives a description of the numerous systems of arrangement of pipes, pumps, valves, gauges, drops, blow-offs, etc., to meet many varied conditions.

Numerous devices are described and illustrated, including condensers, heaters and purifiers; and in a manner such as to avoid giving the impression that the writer is attempting to advertise the product of any particular manufacturer. The text embodies a human interest element in the treatment of plant design so as to give some consideration of the comfort and efficiency of the employees who are to keep the plant in operation. The relation between the contractor, buyer, engineer and operator are dealt with, and the whole work gives the appearance of being based upon extensive practical experience of the writer.

Electro-Magnetic Ore Separation. By C. Godfrey Gunther. 193 pages. 81 illustrations. Price, $3 net. New York: McGraw-Hill Book Company.

A patent was awarded in England on a process for separating iron minerals by means of a magnet in 1792 and magnetic separation of magnetite and apatite began in New York State in 1852. But rapid progress in magnetic concentration has been made in recent years. Aside from an excellent chapter in Ingalls' Canadian zinc report, no comprehensive review of the subject has been available in book form. For this reason Mr. Gunther's book is a welcome addition to metallurgical literature.

"The book has been prepared to gather into convenient form the published information on the magnetic separation of ores. The compilation has been supplemented by data from the writer's observations and an extensive correspondence with mill managers and manufacturers. It has been attempted to include only that which is of present commercial importance." It is essentially a practical book and its chief value lies in the description of commercial apparatus and processes, while with respect to the critical discussion of principles of magnetic separation the book should be strengthened in future editions.

There are eight chapters: Magnetism applied to ore dressing; principles of magnetic separation and preparation of the ore for treatment; separators for strongly magnetic materials; separators for feebly magnetic materials; the concentration of magnetite ores; the separation of pyrite and blende; the separation of siderite from blende; separation of miscellaneous ores and minerals.

Electrochemical and Metallurgical Industry

VOL. VII. NEW YORK, NOVEMBER, 1909 No. 11

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH.D.....*President*
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Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, NOVEMBER, 1909.

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New York Meeting American Electrochemical Society.

On another page will be found the very interesting program of the autumn meeting of the American Electrochemical Society, to be held according to the custom of recent years in New York City. The program of papers is very full, almost too full for three sessions, and includes an experimental lecture of general interest by Dr. Edgar F. Smith, on advances in electrochemical analysis, in which field he has done such revolutionary work. From abroad a paper has been contributed giving the latest information on the Badische Company's new process of fixation of atmospheric nitrogen, which, as our readers know, has aroused so much interest. There is a goodly number of papers on electric furnaces, on electrolytic processes, and on metallurgical subjects. We also notice not less than three papers on dry cells. The smallness of the dry cell makes most people overlook the importance of this industry; but a reliable estimate made a few years ago of the number of dry cells used in this country gave not less than 30,000,000 to 50,000,000 per year. The program of the papers appears to be well balanced with respect to the different fields covered by the authors. It would be regrettable, however, if the large number of papers—there being 22 announced—would prevent their adequate discussion.

* * *

The program of the entertainments is very attractive. The social features have always been prominent in the conventions of the Electrochemical Society and have always been greatly enjoyed. We may be sure that the coming meeting will be no exception. A whole day has been set aside for the excursion to the Bayonne chemical and metallurgical industries. Not less than eight plants will open their doors to the society, and the excursion promises to become the most interesting that has ever been made by a technical society to this rapidly growing industrial center in New Jersey. With the regrettable exception of one interesting metallurgical works all other important companies have extended their invitations to the society. To Mr. T. J. Parker is due chiefly the credit for having prepared, with great trouble, this attractive program. At the professional sessions the society will be the guest of Columbia University and of the Chemists' Club. The Chemists' Club will also be the host of the society at one of its famous smokers on Saturday night, and on this occasion "section Q" should find its opportunity.

The Dry Blast Process.

In this issue we publish a paper presented by Mr. R. S. Moore at the recent meeting of the Iron and Steel Institute, on the fuel economy of dry blast as indicated by calculations from empirical data, in which he stated and argued very clearly and convincingly the principle that "removing the moisture before it enters the furnace is equivalent to utilizing a corresponding amount of heat in melting the iron and fusing the slag." Since these two items only get some 18 per cent of the total heat

generated in the furnace, and since this usefully applied heat is really the governor of the whole furnace running, the criterion of its efficiency, it follows that every 1 per cent of the heat of the furnace saved to the tuyere region or smelting-down zone represents 1 18th = 5.5 per cent saving of fuel to the furnace. This is exactly the view which has been repeatedly advocated in the columns of this journal, and in our reviews of this subject. We agree entirely also with Mr. Moore's comparison of the saving effected by hot blast and that by dried blast, the two are directly analogous and comparable.

* * *

Mr. Moore, however, states that "it is a well-known fact that for the economical reduction of iron oxide in the blast furnace, as large a proportion as possible must be reduced by carbon monoxide." Here Mr. Moore lays down a dictum which is only a partial truth, and which is often wrong. When well-dried blast is used, for example, a furnace works very economically and a smaller proportion of the reduction is done by the reducing gas, as can be conclusively proved by analyzing the running of the furnace. Mr. Moore is thus led astray in his further consideration of the modus operandi of hot blast, and ends by concluding that uniformity in the mixture content is a more potent factor in the economy of the furnace than low moisture content. In the discussion it was brought out that the Dowlais furnace working on dried blast had shown an increased output of 15 per cent, the Cardiff furnace a diminished coke consumption of 17 per cent; also that the United States Steel Corporation was operating three furnaces on dried blast, had plans made for three more, and was preparing plans for 20 others

Subway Air.

Ever since the New York Subway was opened, there have been complaints concerning its depressing atmosphere. In a recent letter to the New York *Times*, Mr. John T. Morrow writes: "The majority of us have had the experience of entering a subway train feeling fresh and full of vigor, and emerging from the same train in a few minutes feeling stupid and depressed. This is simply due to the fact that we have been breathing, over and over again, air far too low in oxygen to be of proper use to our lungs, and at the same time containing tremendous quantities of bacteria in suspension." Mr. Morrow proposes the use of ozone for the purification of the air. He suggests that several ozone apparatus of small size be placed in each car of subway trains and connected to the electric lighting circuit. The ozone would destroy not only a large portion of germ life, but Mr. Morrow thinks that the larger amount of oxygen in the air, produced thereby, would have a stimulating rather than depressing effect on the passengers. The experiment would be well worth trying. The cost would be chiefly the first cost of the ozone apparatus and accessories (converters and high tension transformers). Aside from maintenance and repairs, the cost of operation would be practically nihil. That the ozone would be effective in destroying bacteria by oxidation, there can be no doubt. The only question is where to take a new supply of oxygen from. Of course, if ozone apparatus are installed in a subway car, they can do nothing but transform the oxygen which is present in the air in the car into ozone, according to the equation: $3O_2 = 2O_3$. They cannot create new oxygen. In Europe, where oxygen apparatus are used on a larger scale than in this country for the purification of air in buildings, the practice is to install a combination of fan and ozone apparatus in a hole in the wall, so that fresh air is constantly supplied from the outside into the building and at the same time the oxygen is transformed into ozone. Some similar arrangement has been suggested for mine ventilation, where the ozone apparatus with ventilator would be installed at the top of a shaft. (Obviously for safety means, the use of ozone is impossible in coal mines.) If ozone apparatus is to be installed on subway trains, they must be used in connection with fans which supply fresh air from the tunnel into the inside of the cars. How far this will be successful can only be found out by experiment.

* * *

A few years ago Dr. R. Von Foregger suggested the use of fused sodium peroxide for the same purpose. The scheme is ingenious; it is based upon the reaction between sodium peroxide and water. This yields sodium hydroxide and oxygen. Thus we get a fresh supply of oxygen. But more than that, the sodium hydroxide produced will absorb the carbon dioxide given out from the lungs of the passengers. The method, therefore, yields not only fresh oxygen for the lungs, but takes care of the carbon dioxide given out by the lungs, thus regenerating the air in correct proportions. The method has been successfully used in connection with submarine boats, in case of mine accidents, etc. Whether it could be used on subway trains with commercial success is chiefly a question of cost. The first cost of apparatus would probably be less than with ozone apparatus, but the cost of operation would be high, due to the large quantities of sodium peroxide which would be consumed. The fact that gradually all passenger traffic to the business section of New York—whether from northern Manhattan or New Jersey or Long Island—will be carried out through tunnels, renders the problem an important one for public health. The fact of the existence of a Public Service Commission makes it probable that some day something will be done to remedy the conditions. So much has been accomplished in recent years in developing new methods of producing oxygen gas cheaply for autogenous welding, that we may hope an effective and fairly inexpensive solution of the purification of subway air will also be found if the above suggestions should prove impractical for some reason.

Commercial Efficiency.

In the discussion of the relative merits and demerits of any process or machine there is always more or less talk about its efficiency. But, as Mr. James Swinburne once remarked, efficiency is a common by-word of the professional politician and reformer. Engineers should rather speak of efficiencies and define in each case what particular ratio of the actual to the ideal quantity they mean. Thus, in the production of caustic soda and chlorine by electrolysis of a common salt solution, we may consider the electrolytic cell alone and speak of its amp-hour efficiency, which, in general, will not be the same for the production of chlorine as for the production of caustic soda. In either case it represents the ratio of the real output to the ideal output which, according to Faraday's law, would be obtained if the electric current produced nothing but the desired reaction.

Or, we may speak of the watt-hour efficiency of the cell, which gives the ratio of the actual output to the ideal output, which would be obtained, if all electrical energy had been transformed into chemical energy producing the desired reaction.

* * *

But for commercial purposes it is necessary to take a wider view. The electrolytic cell is only one part of the whole installation, and the commercial object must be to make as much money out of the given total installation as possible. This is to a certain degree possible by pushing the output of the whole plant at the expense of the efficiency of the electrolytic cells. This fact was very well brought out in the paper of Dr. Backeland on three years' practice of the Townsend cell, published in our July issue. Running with a density of 100 amp per square foot, a current efficiency of 97 per cent or 98 per cent can be attained. Running with a density of 150 amp per square foot the current efficiency is only 95 per cent. But the fact that the output of the plant is thus increased 50 per cent with the same interest on plant and the same cost of the operating staff, while the cost of repairs and cost of power have been but slightly increased, makes it good business to increase the capacity of plant at the sacrifice of the highest perfection of technical economy. In general, the money-making ability of a plant may be considered as the product of technical efficiency (intensity factor) and output (capacity factor), just as the power of a waterfall is the product of the height of the fall and of the quantity of water

* * *

The same principle was used by Mr. Carnegie in the conduct of his steel business. It should not be lost sight of now by electrometallurgists when the electric furnace enters the immense field of production of structural steel. As we have often pointed out, what makes the future of the electric steel furnace most promising is the fact that in recent years consumers have insisted more and more on better steel and have become accustomed to favor open-hearth steel very decidedly over Bessemer steel. The danger that Bessemer plants would become useless in time did exist. It is here that the electric furnace has an immense field of usefulness if as an adjunct to the converter it can make steel of open-hearth or better quality at the same cost or more cheaply. It thereby gives the converter a new lease of life. It forms in this case a link between converter plant and rolling mill. Naturally, at present, the electric furnace is still the weakest link in the chain. To run the whole plant at maximum efficiency, the first and most important requirement is to make the electric furnace as reliable in operation and as uniform in production as the two other ends of the chain—the converter plant and the rolling mill. Simple, strong and reliable construction of the electric furnace are now of main importance, even if the efficiency is somewhat lower or some materials of construction are more expensive. There will be much to do later on for the designer to improve details in design, when once the electric furnace has conquered the steel field by simple and most ordinary reliability of operation

The Stupendous Rate of Recovery of the Iron Industry.

The production of pig iron in the United States has reached a new record rate in the past two months, having easily passed the 30,000,000-ton mark, the best rate attained previous to this movement having been 28,000,000 tons, in October, 1907, while the best output for 12 consecutive months was about 27,150,000 tons, in the 12 months ending Oct. 31, 1907. It is difficult to grasp the magnitude of the swings in production, for, meanwhile, in January, 1908, the rate of pig-iron production dropped to not over 13,000,000 tons. Expressed in terms of value the variations are more impressive. Pig iron itself, of course, is nothing; it is merely the raw material of the iron foundry or the steel mill. The tonnage of finished product, in the form of iron and steel castings, and rolled and forged iron and steel, slightly exceeds the tonnage of pig iron, for the decrement in actual loss of iron and elimination of metalloids, which are weighed in the pig iron but do not appear in the finished product, is more than made up by the increment due to the re working of old material and the use of ore in the open-hearth steel furnace. Taking it all in all, the average value of the finished product of the iron and steel industry probably lies not far from $40 a ton, so that a change of a single million tons a year in the rate of pig-iron output means a change of not far from $40,000,000 a year in the value of the industry's output

* * *

Notwithstanding the great excess over the last high record rate the iron industry is not yet employing its maximum capacity, so great has been the increase in the past two years. In our issue of January, 1908, we reviewed the course of the industry in 1907, observing that a rate of 28,000,000 tons a year had been reached in October, while at Jan. 1, 1908, there was new furnace capacity under construction amounting to 3,500,000 tons annually. While October is normally a record-breaking month, so that the performance of that month could not by itself be taken as proof of the possibility of maintaining the rate for a year, the fact was that a number of furnaces had played out on account of the strain of a campaign of almost three years of steady driving, and the actual capacity at the close of the year was really about 28,000,000 tons. Since then the greater part of the 3,500,000 tons of new erection has been brought to completion, and while the actual rate of production exceeds 30,000,000 tons a year, there are statistics which show that the merchant blast furnaces are not making as much pig iron as they did in 1907, although there have been some accretions to their ranks. Additional blast furnaces have been projected since Jan. 1, 1908, and the industry is making for a capacity, by next midsummer, of between 32,500,000 and 33,000,000 tons.

* * *

Stupendous as are these increases, they are but in line with the precedents of the industry Decade after decade the industry has doubled its output Obviously, the breaking down of the geometrical rule of progression must come some time, but the time is not in sight. Presumably the rule will break down as to pig iron sooner than it will as to the production of finished material, for the reason that larger and larger tonnages of old material will come back for reworking. Thus far our store of iron is too new for much of it to require reworking, and the tonnage of old material coming out each year is quite modest. Fully one-half of all the pig iron which has been made in the United States has been produced in the past 10 years, and considerably more than three-fourths in the past 20 years. Despite its present size the industry is really very new

New York Meeting of American Electrochemical Society.

The autumn meeting of the American Electrochemical Society will be held in New York City on Oct 28, 29, and 30.

A session for the reading and discussion of papers will be held in the afternoon of Thursday, Oct. 28, at the Chemists' Club, beginning at 1:30 p. m. Two sessions for the reading and discussion of papers will be held on Saturday in Earle Hall, Columbia University, one beginning in the morning at 9:30 and the other in the afternoon at 2 o'clock. The whole of Friday will be spent in an excursion to the chemical and metallurgical industries of Bayonne, N. J.

Friday evening a subscription dinner will be held at the Hotel Cumberland. On the evening of Saturday the society will be the guests of the Chemists' Club at a smoker in their clubhouse. Hotel headquarters are at the Cumberland, Fifty-fourth Street and Broadway.

The program for the **excursion on Friday** is as follows:

Members and guests will meet in the waiting-room of the station of the Central Railroad of New Jersey in Jersey City at 8.30 a. m. (This station can be reached from New York by ferries either from Liberty Street or Twenty-third Street, not from New York in any other way.)

A special train will take the party to the Constable Hook section in Bayonne, where the forenoon will be spent. In the afternoon plants in the Newark Bay section of Bayonne will be visited.

At noon a lunch will be served at one of the shore resorts on the Kill von Kuhl. The Mayor of Bayonne, Hon. Pierre P. Garven, will there welcome the society to Bayonne.

The following companies have given permission to visit their plants:

Standard Oil Company (oil refineries).

National Sulphur Company (refining of sulphur).

Pacific Coast Borax Company (manufacturers of borax and boric acid).

Gröndal briquetting plant at the works of the General Chemical Company. (The first American installation of the Gröndal process.)

Babcock & Wilcox Company (water-tube boilers and adjuncts).

Electro-Dynamic Company (interpole motors for wide-speed variation).

Electric Launch company (submarine vessels, etc.).

Industrial Oxygen Company (oxy-acetylene welding and cutting apparatus).

The party will return to New York by special train in time for the banquet in the evening.

It is to be clearly understood that while the above-named companies have given permission to the society as a whole to visit their works, members interested in a competitive process are expected not to visit that particular plant. Thus, the Standard Oil Company has given permission under the condition that no one connected with the refining of oil will be allowed to visit their works. Similar conditions have been made by the Babcock & Wilcox Company, the Pacific Coast Borax Company, and the National Sulphur Company. The different plants are, however, of such a diversified character that every member will find it profitable to take part in the excursion.

Railroad tickets for the excursion will be distributed to members and guests when registering.

Admittance to plants to be visited will be granted only to members and guests wearing the society badge.

Since a special program has been arranged for entertaining the ladies on Friday, ladies are not expected to take part in the excursion to Bayonne.

The **program of papers** to be presented at the three sessions is as follows:

Thursday Session.

The Titanium Arc. By W. S. Weedon.

The Element Boron. By E. Weintraub.

A New Electrolytic Method for the Preparation of Explosive Antimony. By R. C. Palmer.

Advances in Electrochemical Analysis. By Dr. Edgar F. Smith. (This is an experimental lecture to be held on special invitation by the board of directors. It is scheduled at 3 p. m.)

Saturday Morning Session.

The Preparation of Silundum. By S. A. Tucker, H. F. Kudlich and E. M. Heumann.

The Laws of Electrode Losses in Electric Furnaces. By Carl Hering.

Furnace Electrode Losses. By C. A. Hansen.

Electrode Losses and Furnace Efficiency. By E. F. Roeber.

A New Method of Measuring Mean Thermal and Electrical Conductivities of Electrodes. By Carl Hering.

The Practical Conductance of Electrolytes. By Joseph W. Richards and W. S. Landis.

A New Theory of Corrosion. By Maximilian Toch.

Electrolytic Preparation of Calcium. By F. C. Frary.

Calcium Carbide. By M. de Kay Thompson.

An Electric Furnace for Production of Pig Iron. By Edward R. Taylor.

Saturday Afternoon Session.

Evolution and Present Status of the Dry Cell. By J. W. Brown.

Dry-Cell Tests. By F. H. Loveridge.

Some Characteristics of Dry Cells. By C. F. Burgess and Carl Hambuechen.

The Manufacture of Air-Saltpeter by the Process of the Badische Anilin & Soda Fabrik. By C. Schönherr.

Power for Electrolytic Copper Refining at the Buffalo Smelting Works. By W. L. Spalding.

A Process for Simultaneously Cleaning, Annealing and Zincing Wire by Electrochemical Cementation. By Alfred Sang.

Notes on Zinc, Copper and Brass Dusts. By Alfred Sang.

Alloys of Copper with Electrolytic Iron. By C. F. Burgess and James Aston.

For the **entertainment of ladies** the following program has been arranged:

Thursday afternoon, Oct. 28, ladies' tea and reception at the Waldorf-Astoria, by invitation of Mrs. W. H. Nichols.

For Friday, Oct. 29, the ladies' committee has arranged the following automobile trip for the visiting ladies: Leave Hotel Cumberland at 3 p. m., drive through Central Park, Riverside Drive to Claremont Restaurant, where light tea will be served at 4 p. m. Return to Hotel Cumberland at 5.30 p. m.

Members and guests are invited to bring ladies to the subscription dinner at the Hotel Cumberland, Friday evening.

Ladies are also included in the invitation to lunch on Saturday, Oct. 30, noon, at Columbia University.

On Saturday evening, visiting out-of-town ladies are invited by the ladies' committee to a theater party, leaving Hotel Cumberland at 8 p. m. On the same evening the members of the Society are the guests of the Chemists' Club.

Iron-Ore Industry of Cuba.

The iron ores which have been mined in Cuba up to the present time consist largely of hematite and magnetite and are obtained near Santiago, in the Province of Oriente (Santiago). Recently large deposits of brown ore have been attracting considerable attention, especially those of Mayari and Moa fields in Oriente Province and those of the Cubitas field in Camaguey Province. No ores of this type have been mined, however.

The following table, taken from a report by E. C. Harder, of the United States Geological Survey, issued as an advance chapter from "Mineral resources of the United States, calendar year 1908," shows the shipments of iron ore from Cuba since the opening of the mines in 1884:

SHIPMENTS OF IRON ORE FROM MINES IN THE PROVINCE OF ORIENTE (SANTIAGO), 1884-1908, IN LONG TONS.

1884	25,295
1885	80,716
1886	112,074
1887	94,240
1888	206,061
1889	260,291
1890	363,842
1891	264,262
1892	341,654
1893	351,175
1894	156,826
1895	382,494
1896	412,995
1897	454,285
1898	168,339
1899	377,189
1900	446,872
1901	552,248
1902	699,734
1903	623,621
1904	387,273
1905	561,159
1906	640,574
1907	681,393
1908	819,434

By far the larger proportion of this ore came to the United States, the imports from Cuba in 1908 being 579,668 long tons. This was about three-fourths of the total imports of iron ore; in 1907 Cuba supplied a little more than half the ore imported.

The Iron and Steel Market.

The finished steel trade has been less active in October than in September, as regards buying and specifying, but this appears to have been due to the previous activity, whereby buyers are covered and mills are sold up for a fair distance ahead.

An exception is noted in sheets and tin plates, in which lines order books have been opened for deliveries to April 1, following the advances of 10 cents per 100 lbs. made Sept. 28. The demand in these lines is quite heavy.

Wire and pipe mills adhere to their practice of not selling material beyond that which can be specified for shipment within 60 days, and as bookings had already been heavy the current pace of bookings is below normal.

In plates, bars and shapes the mills are not only filled with specifications practically to the end of the year, but have a large tonnage on books for first quarter delivery. They have become rather reluctant to accept business for first quarter, as a large part of the legitimate demand from consumers is covered, and it is not desired to sell so far ahead to the jobbing trade. For the present quarter they cannot accept much business, being already filled.

The finished material market is taking a breathing spell and does not promise any important developments for a while

Individual steel mills have been making fresh production records in October, while the industry as a whole has reached a rate of output never before attained. Pig-iron production in October has easily been at a rate of 30,000,000 tons a year, which compares with a maximum rate of 28,000,000 tons a year in 1907, this rate being attained in October of that year. The difference of 2,000,000 tons does not represent the full advance made by the steel trade proper, for the reason that the merchant furnaces, supplying the foundry trade, lack not far from 1,000,000 tons of having reached their former gait, the steel works furnaces having correspondingly increased theirs.

An evidence of the pressure the steel works have been under is found in the large purchases of merchant Bessemer pig iron made lately by five large independents in the Central West—Lackawanna Steel Company, Cambria Steel Company, Jones & Laughlin Steel Company, Republic Iron & Steel Company and Youngstown Sheet & Tube Company. These interests were aligned to be practically self-supporting in the matter of pig iron, but under pressure their steel departments have been making for a rate to which their blast furnaces were unequal. In September and October they have bought merchant Bessemer pig iron for forward delivery to the extent of about 250,000 tons for the fourth and first quarters. In other words, they prepared to consume Bessemer iron at a rate 500,000 tons a year in excess of their own production.

Their combined furnace capacity is about 4,000,000 tons annually.

This movement is quite in keeping with past experiences. Under pressure a steel works shows more flexibility than a blast furnace, while another element is that it is more economical to have an excess of steel making than an excess of pig-iron making capacity, if there must be a difference.

The general trend in railroad buying is toward an increase. This matter of railroad buying is more or less independent of the general purchasing disposition of the country, and in the revival the railroads have been slower than other interests in coming into the market.

Their purchases are steadily increasing, but remain far below the rate in 1906.

Pig Iron.

Bessemer pig iron has continued its advance, having moved from $16.75, valley, to $18 during September, and from $18 to $19 during October. Among important purchases were about 65,000 tons by the Cambria Steel Company at $18 and $18.50, valley, and, later, 20,000 tons by the Republic Iron & Steel Company at $19. The total transactions in Bessemer pig iron since Sept. 1, chiefly at flat prices, but including 38,000 tons on sliding scale contracts and 25,000 tons arranged to be smelted, the consumer furnishing the ore, have amounted to about 350,000 tons, the largest transactions recorded for two consecutive months in many years. Foundry iron has been fairly active in New England, but has been relatively quiet in the Central West. The valley market (90 cents higher delivered Pittsburgh) stands at $19 for Bessemer, $17.25 to $17.50 for basic, $17 to $17.50 for No. 2 foundry, $17.75 to $18 for malleable and $16.25 to $16.50 for forge. The Birmingham market is strong at $15.

Unfinished Steel.

Billets, sheet bars and rods have almost disappeared from the market, producers being so well engaged in their own finishing mills. Chicago reports no market at all, the East has advanced, with very limited offerings, and there are only occasional lots available in the Pittsburgh market. There is inquiry for sheet bars for first quarter delivery, but no sellers have been found as yet. Prices at Pittsburgh may be quoted largely nominal as follows: Bessemer billets, $26; open hearth, $26 to $26.50; sheet bars, $27 to $28; rods, $32.

Finished Materials.

Prices stand as follows, f. o. b. Pittsburgh except where otherwise noted.

Steel bars, $1.40 to $1.50, base.

Iron bars, $1.60 to $1.65, base; Chicago, $1.50 to $1.55.

Plates, $1.50 to $1.60.

Shapes, $1.50 to $1.60.

Standard rails, $28 for Bessemer and $30 for open hearth, f.o.b. mill, except Colorado, light rails, 30 lb. to 40 lb., $28.

Sheets, 28 gage, black, $2.30; galvanized, $3.35; corrugated roofing, $1.60 per square for painted, $2.85 for galvanized.

Merchant steel pipe, extreme price, 80 and 5 off list; wrought-iron pipe, 75 and 5 off list.

Plain wire, $1.60; wire nails, $1.80, base; painted barb wire, $1.80; galvanized barb wire, $2.10.

Institute of Metals.

The autumn meeting of the (British) Institute of Metals was held in Manchester on Oct. 14 and 15. Among the papers presented we note the following:

J. H. Andrew and C. A. Edwards, on "the constitution and properties of the ternary alloys aluminium-copper-tin."

C. O. Bannister and H. J. Tabor, on "the surface appearance of solders."

H. W. Greenwood and F. J. Brislee, on "the technical assay of zinc."

J. S. Glen Primrose, on "the production of pure spelter."

E. L. Rhead, on "some causes of the corrosion of copper and brass."

Prof. C. A. M. Smith, on "the elastic breakdown of non-ferrous metals."

Prof. T. Turner and M. T. Murray, on "the copper-zinc alloys—a study of volume changes during solidification."

Abstracts of some of these papers will be found in the Synopsis in this issue.

Sir William White was the first president of this new society devoted to the metallurgy of non-ferrous metals, while Sir Gerard Muntz is the president-elect. Mr. G. Shaw Scott, Caxton House, Westminster, S. W., London, is the secretary.

Incidental Problems in Gas-Producer Tests.

As part of its investigation of methods for increasing the efficiency of fuel resources, the United States Geological Survey is studying the general problems involved in the economic use of fuels in gas producers. Among many incidental problems of prime importance that have arisen in the course of this study are those of determining, under practically constant conditions, the duration of gas-producer tests necessary to reduce the possible error to a minimum and of determining the differences of temperature in the fuel bed of the gas producer and the influence of such differences on the chemical reactions taking place within the producer.

In attempts to improve the gas producer considerable attention has been given by manufacturers to such problems as those of fixing or isolating the combustible components of the tar, utilizing the waste heat of the producer for the generation of the steam required by the plant, and applying the suction principle to bituminous coal and other tarry fuels. Little study, apparently, has been given to the physical and chemical conditions most suitable to the formation of hydrogen and of carbon monoxide, with a view to regulating the percentages of these gases in generators using fuels other than anthracite coal or charcoal.

Reports on the two problems first stated above are given in Survey Bulletin 393, which can be obtained free of charge by applying to the Director of the Survey at Washington.

The bulletin consists of two papers, one, by R. H. Fernald and C. D. Smith, on the factors affecting the proper length of tests, the other, by J. K. Clement and H. A. Grine, on temperature differences in the fuel bed.

Messrs. Fernald and Smith, summarizing the results of their experiments, state:

"That throughout a test the fuel bed should be maintained in uniform condition, with regard to both the character of the fire and the thickness of the bed.

"That failing in this, special care should be exercised to see that the fuel bed is in the same condition and of the same thickness at the close of a complete test, or end of a test period, as at the beginning.

"That a test should never be started when the producer has been standing idle for some time with 'banked fires,' as the fuel bed will not be in the average condition under which it will be required to work during the test.

"That if, as the appointed hour for closing the test approaches, the fuel bed is not in the proper condition, the time of closing the test should be postponed until the bed naturally assumes the proper thickness and character. No forcing of conditions should be allowed simply to bring the test to an end at a previously determined hour."

Messrs. Clement and Grine report that:

"Temperature observations were made and gas samples taken in different parts of the fuel bed of the gas producers. The temperature was found to be highest at the bottom of the fuel bed and to decrease from this point to the top of the bed.

"The temperature of the inner region of the fuel bed was found to be 300° or 400° lower than that of the outer layers. A corresponding inferiority in the quality of the gas in the center of the producer could not be established; probably on account of the defective method of sampling.

"It has been suggested that by an improvement in the method of admitting the draft to the fuel bed a more uniform distribution of temperature, and consequently a gain in the capacity of the producer and in the quality of the gas, might be obtained.

"Reference has been made to recent experiments by one of the authors which have established 1300° C. as the lower limit of temperature for the formation of a gas rich in CO."

CORRESPONDENCE.

Graphite Electrodes.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—In my article on furnace electrode losses which appeared in your August issue, I made the statement that graphite electrodes could not be purchased in lengths greater than 40 in.

In the course of a recent conversation with Mr. Speiden, of the Acheson Graphite Company, I learned that 45-in. electrodes will be made up on order, and that shortly the company expects to be able to furnish 60-in. lengths.

The availability of longer electrodes will certainly be appreciated by those who use this material.

Schenectady, N. Y. C. A. Hansen.

Electrode Losses.

To the Editor of Electrochemical and Metallurgical Industry:

Sir.—My article in your last issue has been criticised on the ground that the formulas read in inches, centigrade degrees and calories instead of centimeters or Fahrenheit degrees and thermal units, and it has been claimed that this is inconsistent.

I do not agree with the latter. The reason I used inches was because that is the common unit of measurement in this country; and the reason I used the centigrade scale and calories was because most data in books and researches is given in these units, and most pyrometer scales read in centigrade degrees. I therefore used the units which I thought were in most general use in this country in connection with furnace work, and I still believe that the units I used are the most generally acceptable ones.

For the benefit of those who desire to use other units, however, I have calculated the formulas in terms of the other units. They are as follows:

When all the quantities are in terms of centimeters, gram calories and centigrade degrees, hence in absolute units (except the current), the constants in the original formulas (18) to (26) will be the same; that is, the formulas are equally applicable to either set of units, provided those units are used consistently throughout.

When T is in Fahrenheit degrees, and k is in terms of thermal units for 1 in. cube and 1° Fahr., that is, pound-Fahrenheit units commonly represented by b.t.u., and if L, S and r remain in inch units as originally specified, then the constant 4.186 in formula (18) becomes 1055.; the constant 2.894 in formulas (19), (20), (21) and (24) becomes 45.93; and the constant 0.3456 in formulas (22), (23), (25) and (26) becomes 0.02177.

Philadelphia, Pa. Carl Hering.

Essentials of Professional Success in Mining and Metallurgy.*

By John Hays Hammond.

I am often asked what I regard as the essentials of professional success in mining.

First, and above all other considerations, I would place the possession of character.

An honest, clean cut, straightforward, conscientious young fellow, ambitious, persevering and last, but by no means least, level-headed, would, in my judgment, possess 75 per cent of the essentials of success; while in relative importance, I would not attach more than 25 per cent to the possession of a technical education. And I say this without in any degree depreciating the inestimable value of a technical education.

Without character, the professional monument of the engineer would be as unstable as an edifice where the mortar is deficient in lime. Therefore, I urge you to persevere in the development of character in its widest sense, and especially ever to be jealous of your reputation for integrity.

Where ye feel your honor grip,
Let that aye be your border.

In the mining profession the adage "Make haste slowly" applies with unusual force.

The tendency in recent years on the part of the mining engineer has been to neglect that practical experience so essential to the completion of its professional equipment. It is customary for the young engineer—after spending a few years in sampling mines, etc.—to enter the field as a "mining expert." The inevitable result is that he never acquires the practical knowledge that comes from years of experience in mines, mills and smelters, knowledge indispensable in his subsequent rôle of an expert in the determination of the value of mining properties.

There is to-day a scarcity of competent mining managers. The old, hard-headed practical mine manager who has worked up from the bottom round, step by step, and has acquired a thorough knowledge of all the phases of the mining business, from actual experience, has been superseded by the graduates of the mining schools, who, in many instances, after but little experience step into the management of a mining company.

And yet in spite of this scarcity, it is true that never before in the history of the mining industry are there to be found so highly competent mining managers as to-day, but these are the men who, after having received their technical training in the mining schools, have, like the old-time practical miner, acquired an intimate knowledge of the subject through years of experience in the subordinate positions of mining companies.

Formerly the report of a mining engineer or expert was confined to the geological and other cognate features of a mining enterprise; to-day, the engineer is expected not only to employ in his report information on these subjects, but to give his opinion as to whether the property offered for sale is worth the price asked for it. He is, indeed, an engineer of but limited usefulness if he does not go farther professionally than to present a purely technical report on subjects submitted for his consideration.

While the same responsibility obtains as formerly in the solution of the technical problems, the expert has often to deal with the financial and commercial aspects of the problem. Moreover, if he recommends the purchase of a property he incurs a certain moral responsibility for its efficient management, inasmuch as his professional reputation depends on the realization of his predictions as to the outcome of his clients' investment. For this reason the engineer sometimes passes from the rôle of an expert to that of a consulting engineer, bound to supervise both the technical and the business management of the properties purchased on his recommendation.

For many years I have strongly advocated the evolution of the engineer and expert into that of the "mining man."

There is now interposed between the mining engineer and the investors a class of men known as promoters. To what I regard as the butting in of these mine promoters I ascribe the failure of many mining enterprises. These promoters are, as a rule, men who have but a superficial knowledge of mining. Indeed, many of them have been failures in other walks of life and have gone into this vocation, because of the fact that it presents unusual opportunities of getting rich quickly. Not only are the majority of men in this class incompetent and ignorant about mining matters, but they are very often unscrupulous as well. But here, let me say, that I recognize the fact that there are among these mine promoters men who have a fairly good knowledge of practical mining and who possess undoubted integrity.

It is the promoter and not the honest miner who has brought discredit on the mining business.

As the result of an extensive and intimate experience with miners I can conscientiously say that with but few exceptions I have found them to be honest, certainly as honest as men of any other occupations.

It is hardly necessary to advise you, young men brought up in the West, to cultivate the friendship of the practical miner. I feel sure that a great part of what success I may have attained in my mining career has been due to the loyal friendship and assistance I have received from men of this class.

I should like to see the mining engineer acquire such a knowledge of business methods as to enable him to take the place of the mine promoter. This would prevent over-production, so to speak, on the part of the mining schools of the country, which are annually turning out hundreds of mining engineers. It would also insure that mining investments would be placed upon a more conservative basis, thereby greatly minimizing the risks of such investments.

To the engineer who in that way becomes the mining man to whom I have referred, an interesting and remunerative field for his professional activities would be opened.

I have noted of late, especially on the part of young mining experts, the exhibition of a sense of pride in having "turned down" a great number of mining propositions. I would recall in my own experience as a young engineer, a conversation I had with United States Senator George Hearst, of California. Senator Hearst was at that time by far the most important mining capitalist of the country. I had previously spent several months doing assaying work for him. At the time of which I speak he asked me "how I was getting along?" I replied with a feeling of ill-concealed satisfaction "that I had not as yet made any mistake in recommending worthless mining properties." Whereupon he said, "Well, my young friend, that is good as far as it goes, but have you made any recommendations that have turned out well?" In a crestfallen spirit I had to acknowledge that up to that time I had not; whereupon he said: "Then, I would advise you to go ahead and make a mistake or two and cover these mistakes up as quickly as possible by some brilliant success."

Now, I do not wish to encourage any zeal on your part to make mistakes, but I do wish you to base your claim for merit, not upon the negative virtue of not making a mistake by turning down properties, but upon the successful foundation of mining enterprises through your professional advice and direction.

Do not be from Missouri (no disparagement of that great State is intended) on every mining proposition presented to you. On the other hand, be not over-credulous and an easy mark. Remember that some of the greatest ore deposits being worked to-day were turned down on theoretical grounds by eminent mining geologists. Therefore, be open minded and ready, not unwilling to be convinced. In short, be from Colorado!

As the president of the American Institute of Mining Engi-

*Extracts from Mr. Hammond's commencement address, delivered to the Colorado School of Mines on May 28, 1909. The complete address is published in the *Quarterly* of the Colorado School of Mines, Vol. IV, No. 2 (August, 1909).

neer I delivered an address about a year ago on professional ethics. Some prominent members, however, have dissented from my views on the subject and have reproached me for wishing to inject into the sphere of the mining engineer what they regarded as too much commercialism. Nevertheless, I continue to regard mining as the aim to make a pecuniary profit in the exploitation of mineral deposits, and I do not believe (as I have said before) that the function of the engineer should be limited to the consideration of the academic features of mining problems.

In the address, I referred to the propriety of the engineer making a report for the vendor of the mining property. Such practice has been, I know, generally condemned. But a little reflection will show that the condemnation is not warranted, for it is neither wrong nor unreasonable that the owner of the mineral properties who desires to present such a statement of its nature and probable value as will insure the attention of contemplating purchasers, should, for the purpose, secure the assistance of one who knows how to make such a statement intelligently and in scientific language.

Such a report should, however, be plainly designated a "vendor's report," and the young engineer in making the report should use every precaution against the illegitimate or misleading use of its statements.

There arises also in this connection the question of the acceptance of contingent fees by the engineer. It seems to me that an expert of established and unimpeachable reputation is perfectly justified in recommending the purchase of a property and accepting compensation from the promoters, provided, first, and without qualification, that full publicity be given to the nature of his connection with the enterprise, and, secondly, that his compensation be contingent not upon the successful sale of the property, but upon the subsequent success of the undertaking.

The acceptance of commissions from the sales of machinery, etc., is another subject embraced in professional ethics. In many instances of a similar nature, affecting other professions, this practice seems to be established and condoned, if not avowedly justified, but in the mining profession I can see no justification whatsoever in the practice.

A young mining engineer should be as loyal to the corporation which he serves as to any individual. If he "cannot stand for" the policies or practices of his employer, it would be the straightforward course to seek employment elsewhere.

To retain the respect of his subordinates and thus assure the team work that wins in industrial undertakings, as well as on the athletic field, it is quite as important for the engineer in charge of operations as it is to inspire the confidence of his employers.

To be what is called a "good mixer" is an important qualification for the engineer. This is largely an hereditary trait, it is true, but the tendency to become exclusive and self-complacent can at least be overcome. Most valuable information as to mining developments and conditions in a new district can be acquired second-hand from even the unlettered stage driver of the district, and many an important hint is dropped, in a desultory conversation, in a smoking car.

These suggestions have not the dignity of a homily, but they are nevertheless of practical import.

There are two distinct classes of mining propositions with which the engineer has to deal in his professional capacity. The first is the so-called "gilt-edged" mining investments. Here the engineer exercises great conservatism, not only because there are relatively large sums of money involved, but also because investors in this class of mining are unfamiliar with the mining risks. The second is a class of propositions which, while speculative, are honest and legitimate undertakings. The development of mining prospects belongs to this category. Ventures of this kind should be confined to those who are willing and can afford to take greater risks in the hope of larger profits than accrue from the "gilt-edged" class of mining investments. If the engineer has already established the reputation of being successful in his mining ventures and has formed a clientele, for whom he has made money in these enterprises, he can then afford to take some chance in risking the money of his clients in this more hazardous class of mining propositions. Here I wish to impress upon you the necessity of exercising great discrimination in choosing the capitalists to be associated with you in these respective enterprises. As your experience expands in these matters you will appreciate the importance of this injunction.

In making reports the young engineer should present copious technical data, in case the report is to be submitted to other engineers, but when his report is to be submitted to the capitalist he should have in view chiefly the presentation of economic facts. Many of the reports of young engineers are altogether too voluminous to attract the serious consideration of a busy capitalist.

The last word of advice I have to give is to enjoin upon you the discharge of your civic duties. You should without the undue sacrifice of your professional opportunities, participate, to some extent at least, in the political movements affecting the localities in which you reside, and the welfare of the nation. For upon the welfare of our nation depends in a very large degree the prosperous conditions under which we can best succeed in our professional vocation.

Electric Zinc Smelting.

In our excellent French contemporary, *La Houille Blanche*, December, 1908 (Vol. VII, page 273), Mr. Eugène Fleurville publishes an interesting article on electric zinc smelting with special reference to a process of two French metallurgists, Messrs. E. F. Côte and P. Pierron. The process is of special interest, as it is being carried out on a commercial scale.

General Considerations.

In the usual retort furnaces for zinc reduction only 10 per cent or 12 per cent of the calories set free by the combustion of coal are utilized. In closed electric furnaces operated at a temperature of at most 1800° C., it is possible to utilize 45 per cent or 50 per cent of the calories produced from electrical energy. Hence out of the 6,500,000 calories set free by the combustion of one ton of coal, only 700,000 are utilized in the retort furnace, while in the electric furnace the same thermic effect is obtained by an expenditure of 1,500,000 calories, which correspond to 95 or 100 electrical hp-days.

These figures are confirmed by experience. In the best Belgian and Silesian retort furnaces the amount of coal required per 1000 kg of zinc from 45 per cent to 50 per cent ores is in the average 2.5 tons, while according to tests of electric furnaces one ton of zinc can be extracted from the same ore by 2500 hp-days.

If the cost of coal in the retort furnaces shall be the same as the cost of energy in the electric furnaces, 95 electric hp-days or 100 hp-days must cost as much as a ton of coal, say, 12 francs or 13 francs ($2.40 to $2.60). The electric hp-year will then cost about 45 francs or 50 francs ($11.25 or $12.50). There are numerous enterprises in mountain districts where the cost is less. Electric zinc smelting is, therefore, in a more advantageous position than electric reduction of iron ore.

The cost of wages can be reduced by the electric furnace quite considerably without any doubt. The cost of maintenance of retort furnaces is due chiefly to the renewal of the retorts and may amount to 200 kg of clay retorts per ton of metal. Every zinc smelting plant has, therefore, its own retort factory. The corresponding expense with electric zinc smelting is the renewal of the electrodes, about 30 kg of carbon per ton of zinc; a large electric zinc smelting plant should, therefore, consider the erection of its own electrode factory. It is difficult to compare the cost in both cases, though it seems that the cost of maintenance of electric zinc smelting plants should be

less than that of retort furnaces. In any case, the first cost is less.

It is especially with respect to the reduction of zinc losses, however, that the electric furnace process can obtain a real superiority over present methods. In the Belgian and Silesian plants the loss of metal due to incomplete extraction and escape of metallic zinc vapors through the retort walls is only in exceptional cases below 10 per cent of the zinc contained in the ore, if blende containing from 45 per cent to 50 per cent is treated, and rises to 20 per cent if ore containing 25 per cent is treated. But, since most ores contain not more than 30 per cent, and since mechanical concentration to 50 per cent leaves 10 per cent to 15 per cent of the metal in the residues, it is seen that with present methods 20 per cent or 25 per cent of the metal contained in the ore is lost. On the other hand, with electric furnaces ores with an average content of 30 per cent can be directly treated with a total loss of less than 7 per cent, as is shown by experience on a commercial scale (see below).

However, the chief point to be taken into consideration is the well-known fact that zinc plants using retort furnaces must be located near a coal field or at least near a waterway by means of which coal may be brought cheaply to the zinc plant. The cost of the transport of zinc ore to the reduction plants puts certain localities to a great disadvantage. For instance, in the Pyrenees, in southern France, on the border of Spain, there are large deposits of zinc ore, but there is no coal available, and the transport of the zinc ore elsewhere would be very expensive. But since water-powers are available at the place, electric zinc smelting is the logical solution of this economic difficulty. It is then only necessary to ship the reduced metallic zinc instead of the zinc ore, and this saving in the expense of transportation is alone sufficient to encourage the electric furnace process in such localities.

Côte-Pierron Process.

The Côte-Pierron process is interesting with respect to its features of both reduction of the zinc ore and condensation of the zinc vapor. In order to facilitate the regulation of the temperature in the condenser independently of the furnace operation, these inventors have proposed to employ a column of granulated carbon compressed between two electrodes in a vertical cylinder with refractory walls. Part of the main current is shunted off and passes through the carbon, whereby the latter is heated. The temperature can be adjusted by varying the length of the column or the compression of the granulated carbon particles.

The chief difficulty in zinc condensation is due to the fact that the zinc is set free in a large amount of carbon monoxide. To avoid this disadvantage Côte and Pierron employ a process which is novel at least in its practical application, though it is known from chemical textbooks as a possible reaction. They let the zinc blende react with iron in the fused bath. The iron combines with the sulphur, and the zinc vapors are set free, according to the formula

$$ZnS + Fe = Zn + FeS.$$

This reaction takes place in the electric furnace quantitatively at a temperature relatively low for this apparatus.

This reaction has not been made use of probably because it was considered unsuitable for furnaces heated by coal.

Nevertheless, even this method does not yield pure zinc vapor. The ore even when apparently dry always contains traces of humidity, and its gangue contains more or less carbonates yielding carbonic acid when heated. Further, there is always a certain amount of air within the interstices of the charge when reduced to a granulated form. And this air enters with the ore into the furnace. But steam and carbonic acid gas and air when set free together with zinc vapor, even in small quantities, act energtically on the zinc vapor, which is easily oxidized. The result is the formation of "zinc mist." This is similar to the formation of mist in a cold and moist atmosphere.

The "zinc mist" causes less trouble for the condensation of zinc vapor than does carbon oxides gas, but if special means are not used to reduce it, it will result in the deposition of "zinc dust" in the condensers. This may clog the connecting tubes and form a serious difficulty in getting the zinc in form of liquid metal.

Messrs. Côte and Pierron, in a patent of 1904, avoid this inconvenience as follows: The iron and the zinc blende are fused separately in two crucibles under the action of electric arcs. From these two crucibles, the two fused metals pass into the reaction chamber, where they mix, the mixture being maintained fluid by resistance heating. Into this reaction chamber neither steam nor carbonic acid nor air can enter, since they have been before driven off in the fusion crucibles. From this chamber the zinc vapor enters the condenser.

This furnace has not been tried, however, in practice in this form, since its construction involved certain complications. It was the intention of the inventors to avoid any complications, as they were convinced that electric zinc furnaces, even more than other electric furnaces, must be primarily of greatest simplicity in construction.

Messrs. Côte and Pierron now treat the mixture of the blende and the iron in a single crucible, and then reduce the zinc mist by passing it through incandescent carbons which are interposed between the furnace and condenser. These carbons are kept at the incandescent point in a closed vessel from which air is excluded by means of two electrodes, supplied with shunt current from the main circuit.

The process is of special interest in connection with complex zinc-lead ores, as it permits a practically complete separation of the zinc from the lead. The lead is contained in the blende in the form of PbS. The crushed ore, mixed with comminuted iron particles and a suitable flux, is introduced into the electric furnace, in which it is heated first simply by the walls, which are kept red hot in a manner described later. The lead is precipitated during this first stage of the process and removed from the furnace.

Then the electric circuit is closed and the charge is heated by means of the current. The iron displaces the zinc, which is set free in form of vapor, and is condensed in the condenser, practically free from lead. The iron sulphide collects on the bottom of the furnace in form of a liquid bath, covered by a fused slag. By increasing the heating effect the slag is rendered liquid, and most of the zinc that is contained in it is set free. At the end of this second step of the treatment, the iron sulphide and the slag are tapped from the furnace. A new charge is introduced and the operation begins again.

The form of furnace which is the result of numerous tests of Messrs. Côte and Pierron, to realize the foregoing method in practice, is shown in Fig. 1 in vertical and horizontal sections. *A* is the crucible, the bottom of which contains in its center a projection *b*. The crucible consists in its lower part and side walls of graphite encased by sheet metal and is connected to one pole of the electric circuit. The other pole is connected to the vertical electrode *C*, the lower end of which is above the projection *b*. The roof is formed by the arch *D* of refractory brick. The charge is introduced through the holes *e*, which are closed during operation by means of refractory stoppers; *f* is the tapping hole.

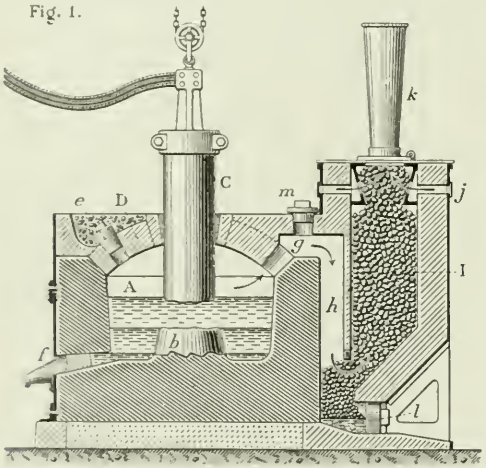
The zinc vapors leave through *g* and pass through a long channel *h* to the condenser *I*, which is formed of a chamber with vertical refractory walls, filled with carbon particles which are kept hot at a temperature of red cherry. The condenser is tapped through the hole *l*. Air can be admitted at the top through *r*, while *k* is a stack, so that it is possible to bring the carbon in the upper part of the condenser to red heat. The downward passage of the carbon is regulated in such a way that the carbon is maintained in the uppermost part of the chamber *I* at a temperature sufficient for the reduction of the "zinc mist" and the condensation of the zinc. The opening *m* is provided for cleaning the channels *g* and *h* in case of clogging. The described method of heating the con-

denser is simpler than by means of an auxiliary electrode. Nevertheless, there would be no difficulty in heating the carbons in *l* electrically. The principle of the apparatus remains the same.

The charge to be treated is placed on the top of the furnace *D*, where it is dried in advance of being introduced into the furnace. When the furnace is tapped, the electrode *C* is lowered and brought into contact with the projection *b*. The feeding hole *e* is then opened and the new charge is rapidly pushed into the furnace, whereupon the feeding hole *e* is again closed and a new charge is placed on top of the furnace for drying.

The electrode *C* now remains in contact with the projection *b*, so that practically all the current passes through *C* and *b* and none through the charge. The charge is, therefore, heated

Fig. 1.



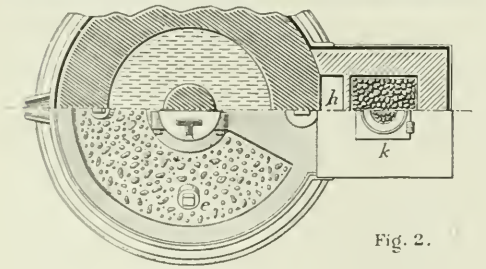


Fig. 2.

FIGS. 1 AND 2.—SECTIONS OF ELECTRIC ZINC FURNACE AND CONDENSER.

simply by contact from the hot electrode *C* and the projection *b*. The lead precipitates and leaves the furnace through the tapping hole *f*, which remains open.

During this time the door *l* of the condenser is also left open, and the pieces of carbon are allowed to slide down in the condenser *I* so that they clean the condenser thoroughly, while the temperature reaches the upper limit of the range within which zinc is condensed. The vapors set free from the fused bath—iron, silica and lime—pass through *h* to the condenser and are arrested by the carbon pieces in the lower part of *h*. They are automatically removed from the condenser whenever the door *l* is opened to tap the molten zinc and let the carbons pass down. It is, therefore, easy to remove any momentary clogging that may occur. This is of great importance.

When it is thought that all the lead which can be removed by precipitation has gone out of the furnace through the tapping hole *f*, this tapping hole *f* and the condenser door *l* are closed and the electrode *C* is now gradually raised so as to heat the charge by resistance and arc heating. Iron sulphide now forms and collects on the bottom of the furnace. But the current does not pass through it, since the current passes essentially through the electrode *C* and the projection *b* and the charge between their two ends. Finally, by simple arc heating, the zinc is set free and the slag is brought into a fluid condition convenient for tapping. At this moment the layer of slag between the electrode *C* and the projection *b* receives practically alone the whole thermic effect of the current. As a result the volatilization of the iron is reduced, the crucible is better preserved, and the electro-thermic efficiency is raised.

After all the zinc has been set free, the furnace is tapped and a new run begins.

Zinc vapor has a tension which increases very rapidly with the temperature, while its specific heat is low. When the zinc vapor leaves the crucible it is at the temperature of 1200° C. or 1300° C. It is, therefore, necessary to bring it into contact with as large a surface of condensation as possible. If this precaution is not taken the zinc vapor will pass along too rapidly while it is at a high temperature. A condensation in form of zinc powder will be the result. In order to get the right conditions of condensation surface, volume and temperature, the cylindrical condenser is filled with pieces of carbon practically at red heat. The zinc vapor rises upward within this column of carbon.

In the moment when it passes from the channel *h* into the condenser *I*, the vapor is still very hot and serves to bring the carbon particles up to the temperature of the reduction of zinc oxide contained in the vapor. While rising upward in the condenser cylinder *I* the vapor cools off by giving its heat to the carbon pieces, which, on the other hand, are sufficiently hot to prevent too rapid a cooling of the vapor. On contact with the carbon surfaces the condensation of the zinc takes place gradually. The little drops of zinc which are formed trickle down on the carbons and form thereby new condensing surfaces of great activity so as to condense more zinc vapor, which is rising upward.

The liquid zinc collects on the bottom behind the door *l*, through which it is withdrawn from time to time.

The carbon monoxide resulting from the reduction of the zinc mist escapes through the stack *k* with the gases of combustion of the pieces of carbon from the upper part of the condenser. Whenever fumes of zinc oxide are seen to pass out of the smokestack it is a sure indication of poor condensation and the conditions must quickly be adjusted, either by regulating the current in the crucible or the speed of combustion or the passage of the carbons down in the condenser.

This regulation of the conditions in order to obtain good condensation requires skilled and attentive workmen just as is the case with retort furnaces. But the electric furnace is a great deal more easily attended to and any correction of the conditions can be done much more quickly and with much less trouble and with less loss.

It might be objected that the use of iron as reducing agent is uneconomical compared with the ordinary process of zinc blende roasting and reduction. But the inventors do not think so. Nine hundred kilograms of iron are required per ton of zinc (1000 kg) to be extracted. The iron sulphide produced contains 36 per cent of sulphur, while the zinc ore, even if concentrated to 50 per cent, contains only 17 per cent. The desulphurization of the iron sulphide withdrawn from the furnaces is believed to be much more advantageous than that of the zinc ore. It can be carried out cheaply by simple methods, and the impure iron thus obtained can be used again in the zinc furnaces.

If it is not desired to regenerate the iron it is used in form of turnings or drillings. The sale of the iron sulphide covers part of the expense of buying the turnings.

Electric Zinc Smelting on a Commercial Scale.

The first experiments with the above process, outside of the laboratory of Messrs. Côte and Pierron, were made in 1906, at Lyon, with a 100-hp furnace. The gas company of the city of Lyon had placed at their disposal for certain hours during the day a direct-current generator giving 1200 amp at 250 volts. This was used in connection with a water rheostat by means of which the voltage could be reduced to 25 volts, which was the difference of potential of the electrodes.

The furnace consisted of a cylindrical crucible of 40 cm inside diameter and 45 cm height, carefully built up of magnesia brick and held together by a metallic casing of 1 m diameter and 110 cm height. On the top of the furnace a hopper was provided for introducing the charge. The electrodes were placed vertically along the central axle of crucible and hopper.

The stationary lower electrode consisted of a carbon cylinder of 20 cm diameter, passing through the bottom of the crucible and projecting 10 cm into the interior. The smaller movable upper electrode was suspended into the furnace through the opening through which the hopper was in connection with the crucible. A conical valve, movable along this electrode and resting on the inner walls of the hopper, closed the furnace. For introducing a new charge this valve was raised. The arrangement was satisfactory in preventing any zinc vapors from leaving the furnace through the hopper.

Two tapping holes were provided, one directly at the bottom and the other 15 cm higher. From the top of the furnace a channel conducted the metallic vapors to the condenser. The compartments provided at the end of this channel to receive the zinc had various forms and dimensions; several of them could be heated externally.

The work with this furnace was not undertaken to solve at once the problem of condensation of the zinc in liquid form, but rather to study some fundamental chemical problems of the process, especially the displacement of the zinc by the iron, the power consumption, the losses of metal, the consumption of the electrodes, and the wear and tear of the crucible, etc.

In these first experiments the composition of the ore, the composition of the gangue, the additions of iron and of flux were systematically varied. The results of one of the last experiments of this series of tests are given as follows:

With an ore containing 46 per cent of zinc, with a silica gangue and a content of not more than 4 per cent of limestone, the charge being reduced to particles of a size from 5 mm to 10 mm, it was possible to smelt per hour a charge of 30 kg of zinc ore plus 13 kg of iron plus 5 kg of lime (the total weight being, therefore, 48 kg). The charging was done every quarter of an hour, 12 kg being charged every time. The furnace was tapped every hour, the bath being very fluid.

The current varied between 1100 amp and 1200 amp at a voltage ranging from 30 volts (during a few minutes after introduction of a new charge) to 65 or 70 volts on the regular operation. The energy consumption was 68 kw-hours

The quantity of zinc retained in the slag was in the maximum 3 per cent of the weight of metal contained in the ore. The weight of zinc powder and condensed zinc obtained per hour was 13.7 kg. This is quite a satisfactory result for such a small furnace in comparison with the output of retort furnaces.

After 36 hours of running the loss of the movable electrode was 7 kg. The wear and tear of the magnesia brick was also satisfactory. After these preliminary experiments the Societé des Fonderies Electriques was formed in May, 1907, to exploit the Côte and Pierron furnace on a larger scale

The program was not to solve all problems at once, but to proceed in two successive steps. The first step included the study of types of furnaces most appropriate for the purpose and the establishment of the cost of operation and possible profits during one year of running a plant of about 500 hp. During this first operation no attempt was made to condense the zinc, the purpose being to produce directly zinc oxide or white zinc in commercial form from low-grade ores. After this first investigation has been successfully concluded, the second step will be to build a plant of 1200 hp to 1500 hp making white zinc. With the different furnaces of this plant in operation it will then be convenient to learn the tricks of handling large volumes of zinc vapors. And with the furnaces in industrial operation the production of condensed liquid zinc is to be gradually increased until the problem of obtaining practically all the zinc in ingots is finally solved. Even now, without special experience, a portion of condensed metal is obtained.

The Société des Fonderies Electriques has successfully gone through the first step of their program outlined above. They rented, in the May of 1907, an old carbide plant which had been abandoned in the Pyrenees at Arugy on the railroad from Pau to Laruns-Eaux-Bonnes in an important mining district which furnishes the zinc blende. These works contain a small water-power plant, with two alternators each of 250 hp, from which alternating current with a frequency of 50 is transmitted at 3000 volts over a line of 900 m length to industrial establishments in the neighborhood.

Several zinc furnaces have been installed in these buildings. In view of the special conditions in this plant it was necessary to modify as little as possible the arrangements, and the furnaces had to be placed at quite a distance from the transformers which lower the voltage from 3000 to the voltage required at the terminals of the furnace. In spite of all precautions taken the power factor of the installation was well below unity.

The transformers can be connected in several ways so as to give either 135 volts or 90 volts or 45 volts. Hardly at any time more than 300 hp is available at the electrodes and very often the furnaces have to be operated alternately. Messrs. Côte and Pierron have first tried various types of furnaces with currents from 3000 amp to 6000 amp and at 90 volts or 45 volts or even 40 volts. They have tried rectangular furnaces with two electrodes in series above the fused bath and other furnaces, also with two electrodes above the bath, but these two connected in parallel, while graphite blocks embedded in the bottom of the furnaces form the other pole. After numerous experiments extending over more than six months they have come back to the cylindrical furnace with one electrode and the graphite crucible forming the other pole. The arched roof is built of fire brick and lined with magnesia brick.

With these furnaces various systems of charging have been tried and the place of the hopper, the speed and regularity of charging have been varied. The advantages and disadvantages of the different systems have been compared with that illustrated in Fig. 1; the latter has finally been adopted.

Whatever the position of the hole through which the zinc vapors leave the furnaces, they get first into the combustion apparatus in which the vapors are changed to oxide fumes, which are then conducted through metallic tubes into large chambers for collection

Numerous tests have been made on the possibility of devising better forms of the combustion apparatus, on the quantity of ore to be introduced, on the temperature most suitable for a good oxidation, on the best speed of passage of the fumes through the chambers and filters. The author thinks that the manufacture of zinc oxide involves its own problems, and he is not sure whether these problems are easier or more difficult than the problems of zinc condensation

The following are the results of the run of a furnace with a single electrode in a graphite crucible:

Total time of series of experiments, 240 hours
Weight of ore smelted during that time, 14,560 kg
Average content, 43.6 per cent
Weight of iron mixed with the ore, 6235 kg.
Weight of fluxes added to the charge, 3480 kg
Mean current, 4300 amp., voltage, 40., power factor, 0.80
Weight of zinc oxide obtained, 6730 kg
Metallic zinc condensed before passage to the combustion apparatus, 182 kg

Zinc content in the slag and iron sulphide, 2.7 per cent.

Consumption of electrodes, 193 kg.

Electric energy cost 65 francs ($13) per hp-year.

The electrodes are not made by the company itself, as the consumption is not large enough. They cost 52 francs ($10.40) per 100 kg. Of these 18 francs ($3.40) are expenses for transporting the 100 kg to the works. The iron is delivered at the plant at 60 francs ($12) per ton and the lime at 15 francs ($3) per 1000 kg. The workingmen get 3 francs (60 cents) in the average per day. Under these conditions the cost of the 6912 kg of oxide and metallic zinc of the above run was 2396 francs (not including general expenses, but including maintenance of the furnaces). The cost of packing and loading the cars is to be added. This brings the total cost up to 2631 francs.

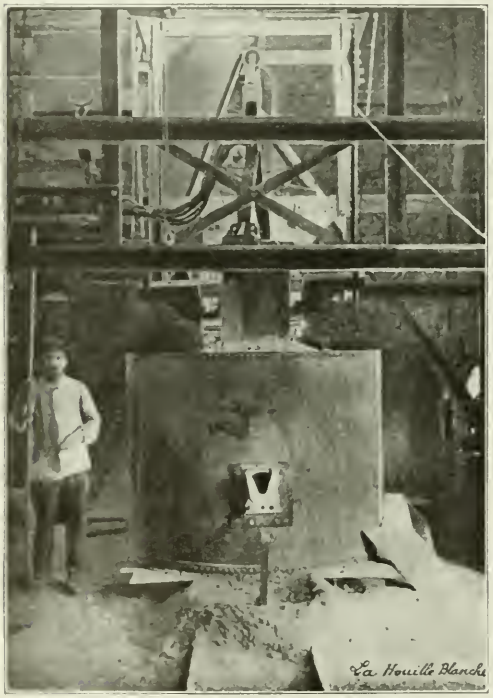


FIG. 3.—VIEW OF ELECTRIC ZINC FURNACE.

The oxide was sold at 46.30 francs per 100 kg, which gives a total income of 3200 francs.

The treatment of zinc blende with iron has, however, been abandoned for the production of commercial zinc white because a small percentage of iron would volatilize and mix with the zinc oxide fumes (1 or 2 per cent, according to the conditions of operation). The presence of this iron in the zinc white is objectionable for certain applications. The zinc condensed to the metallic state, however, contains very much less iron.

In order to obtain directly from crude low-grade ore an absolutely white zinc white of practically the same purity as other commercial zinc white, the inventors have had recourse to another reaction, namely, that of lime and carbon on fused blende. This is given by the equation

$$ZnS + CaO + C = CO + CaS + Zn.$$

In this case the presence of the carbon monoxide is no cause of trouble, since the object is not to condense the metal. It is noteworthy that in the course of tests made with this method there are never found any traces of condensed metal at those places where it is always found when the reaction with iron is carried out.

For eight months one of the furnaces at Arudy has produced zinc white according to the lime-carbon process. The sale of this zinc white has permitted the recovery of a large part of the expenses of the experiments.

One of the furnaces used in these tests is shown in Fig. 3. It is formed by a graphite crucible of 110 cm inside diameter and 65 cm height, covered by an arched roof of magnesia brick and held together by a sheet-iron casing, 195 cm in diameter, which is connected to one of the poles of the electric circuit. The electrode had a cross section of 1000 sq. cm. The cost of the furnace ready to begin operation, with all mechanical and electrical accessories, was 4850 francs ($970).

The charge requires less than two minutes, the tapping three or four minutes at the most. Two men can easily attend to two furnaces of much larger capacity. When the operation is once regulated to suit the treatment of an ore of given composition—which can be done in less than 24 hours—the furnaces operate without any other attendance except the purely mechanical operations of charging and tapping, which are to be carried out by the workingmen at regular intervals.

The working men during this test were unskilled men and had never seen anything of a metallurgical furnace. Their wages varied from 2.75 to 3.25 francs (55 to 60 cents) per day. This shows that the electric furnace is more easily attended than retort furnaces.

The following figures refer to a series of tests in which 76 tons of ore were smelted with a consumption of energy quite similar to those quoted above:

In 600 hours, or 25 days, 28,345 kg of zinc blende, with an almost pure silica gangue containing 2 to 4 per cent of iron, 1 per cent of other metals and analyzing on the average 37.28 per cent of zinc were smelted. The current was 3800 amp at 42 volts, with a power factor of 0.85; 12,384 kg of lime (both for reaction and flux) were used and 3146 kg of carbon. The ore charged into the furnace contained 10,587 kg of zinc, from which theoretically 13,103 kg of oxide should be obtained. The recovery was, in fact, 12,370 kg.

The content of zinc in the slag and calcium sulphide varied during these tests from 1.2 to 1.8 per cent.

The consumption of electrodes was 1286 kg, but this includes 637 kg of electrode ends which were not consumed, and with a better designed plant this amount could be reduced to a certain extent.

Of course, a larger electric zinc smelting works, would erect its own electrode factory and hereby reduce considerably the expense of this item.

The lining of the furnace had to be replaced after two months.

The cost of coke at the works was 39 francs ($7.80) per ton.

The total cost of making these 12,370 kg of oxide was 4598 francs, and they were sold for 6102 francs.

The zinc oxide produced is classed in two brands, according to its whiteness. The larger part, about 70 per cent, constitutes the better quality, while 3 or 4 per cent, constituting the parts recovered in the flues, are returned into the furnace with a new charge.

The two qualities are nearly of the same degree of purity. They analyze 98.6 to 99 per cent of zinc oxide, 0.4 per cent of moisture, 0.2 or 0.3 per cent of iron and 0.5 to 0.7 per cent of silica, lime, and other metals, the latter being present only in traces, since the ore itself is almost free of them. Some 300 barrels, each of 100 kg, have been sold at Marseilles, Paris, and Lyon in competition with German and American zinc white made by other methods.

The author finally remarks that the figures of the tests given above are perhaps less alluring than those given by other experimenters, but the above figures represent true figures from operation on a large scale, and are not estimates based on laboratory experiments.

Electrode Efficiency of Furnaces.

By Carl Hering.

If the voltage between the inside or hot ends of the two electrodes of a furnace be divided by that between the outside or cold ends, a figure is obtained for which the writer has suggested the name electrode efficiency, as it is a true measure of the efficiency of the furnace as far as the loss of power in the electrodes is concerned; for if this figure were 100 per cent, it would mean theoretically ideal electrodes in which there is no loss, while if it is 75 per cent it means that a quarter of the whole energy is lost in the electrodes. Such a figure, therefore, is a measure of the degree of perfection of the function of the electrodes as a means for efficiently conveying the energy into the furnace, apart from all other losses or efficiencies.

In an article on "The Laws of Electrode Losses in Electric Furnaces," published in the preceding number of this journal, p. 442, the writer referred to this electrode efficiency and the interesting constant electrode voltage on which it depends, but owing probably to the brevity of this reference it appears that it was not correctly understood, judging from an editorial remark concerning it. The object of the present article is to endeavor to describe this more clearly, as it has an important bearing on the design of furnaces.

The essential element in this electrode efficiency is, of course, the drop of voltage between the hot and cold ends of an electrode. It was shown in that article that for any given electrode material there exists a curious and interesting minimum drop in voltage below which it is not possible to go without again increasing the total loss. An electrode is, therefore, different from an ordinary conductor of electricity, for with the latter the loss in it can be reduced to any degree to which one desires to go by merely increasing its section and diminishing its length.

The reason for this difference is that there is another loss through an electrode; namely, the heat conducted off by it from the interior of the furnace, which, as it costs quite as much per watt as the loss due to its electrical resistance, is of equal importance, and it is this loss which increases by increasing the section of the electrode or reducing its length. And it is when both of these losses are taken into consideration that it was found that there was a minimum drop of voltage in electrodes below which the total losses again increase

This voltage the writer suggested naming the "electrode voltage," as he found it to be a characteristic physical property of the material, like density, conductivity, etc., and is of use in designing electrodes, of more importance even than the electrical and the thermal conductivities alone; it depends on both of these combined. Neither of the two conductivities alone is a criterion of the suitability of a material for an efficient electrode, as was pointed out in that article, but the electrode voltage is a true measure of this latter quality; the lower this electrode voltage of a material the higher will be the electrode efficiency.

The features of this electrode voltage may be summarized briefly as follows, under the assumed conditions stated in that article:

It is the lowest drop in voltage to which it is possible to go without again increasing the total electrode loss. It has a different value for different materials, but is a constant for each material. It is, therefore, a physical property of the material—that is, it is independent of the length or cross-section of the electrode, or the current passing through it, and, therefore, no changes in these can further reduce it. It is, however, dependent on the temperature drop in the electrode and hence as a constant it must be understood to be for 1 deg. of temperature drop. It increases as the square root of the temperature drops. It bears a fixed relation to the electrical and thermal conductivities combined, and, in fact, is determined by them. It varies as the square root of the quotient of the heat conductivity divided by the electrical conductivity. For 1 deg. temperature drop it is therefore equal to, in volts,

$$e = A\sqrt{\frac{k}{K}} \qquad (1)$$

in which k is the thermal conductivity, K the electrical conductivity and A a constant depending on the units used. For any given temperature drop this value must be multiplied by the square root of that drop. As the electric resistivity r is more commonly used than the conductivity, this formula is more convenient in the form

$$e = A\sqrt{rk} \qquad (2)$$

When r and k are given in terms of cubic centimeters, ohms and gram calories per second, and when the unit of temperature is 1° C., then the constant A will be 2.894 when e is in volts. It will be the same when r and k are given in cubic inch-units instead of centimeters. When the units are cubic inches, ohms, thermal units (b.t.u.) and Fahrenheit degrees, the constant A is equal to 45.93. These values of A are mere mathematical constants and involve no physical properties.

As an illustration of the approximate value which e has for graphite, for instance, assume that $r = 0.000266$ and $k = 0.24$ in cubic inch, ohm, gram calorie, centigrade units, then

$$e = 2.894\sqrt{0.000266 \times 0.24} = 0.0231 \text{ volt.} \qquad (3)$$

That is, for 1° C. drop in temperature and perfect conditions, the least drop of potential in any graphite electrode will be 0.0231 volt, no matter what its size, or what the normal current is; reducing the voltage still more would increase the loss again. It also means that at this voltage only will the hot end of the electrode be raised to the furnace temperature by the C^2R heat, which was shown in the article mentioned above to be the proper condition under which electrodes should be operated to give the best economy of power, for under those conditions only will no furnace heat be lost through the electrode.

Suppose the temperature drop in the electrode is 1600° C.; the square root of this is 40, hence the voltage drop for this temperature range will be $40 \times 0.0231 = 0.92$ volt for any correctly proportioned graphite electrode, no matter what its size nor what the normal current. Hence a 50-volt furnace with graphite electrodes has an electrode efficiency of 96.3 per cent no matter what its size, provided only that it is correctly designed. It is of interest to note that this minimum electrode loss is quite small.

Returning now to the electrode efficiency, it will be seen from the above that as the drop of voltage in the electrode is a constant depending only on the material and the temperature (assuming the electrode to be correctly designed) the designer has no choice left concerning this important factor in the electrode efficiency when the electrode material and the temperature are given; he must take it as it is determined for him by nature—that is, by the physical constants of the material.

The only choice he may have concerning this voltage drop is in the temperature and the electrode material. Ordinarily the temperature is fixed by specification, thus leaving no choice there; the only thing the designer can do is not to exceed this unnecessarily, for instance, by not using an arc if a resistor will answer, as arc temperatures are usually volatilization points. Other and more important considerations than a small gain in efficiency will, however, generally decide this.

The other choice lies in the material. As long as this is limited to graphite and carbon the choice is easily made when the two conductivities of each of these materials are known. But here again a small gain in efficiency should not be allowed to outweigh other and perhaps much more important advantages of one over the other. According to the best figures available at present (which may be only very rough approximations) the electrode voltage of graphite for 1° C. is 0.0231 volt and for carbon 0.0224, the difference is only a few per cent, and therefore of little consequence.

In many transformation devices the usual way of increasing the efficiency is by reducing the internal losses, but from what has been shown above an electric furnace with electrodes differs

from these, at least in the electrode efficiency, in that the electrode loss is fixed by the material and temperature, thus leaving no choice to the designer. All he can do is to reach this minimum loss; he cannot go below it.

Hence, the only way left in which the electrode efficiency can be increased by the designer is by increasing the total voltage of which this drop in the electrode is a fractional part; or, in other words, to produce the required watts in the furnace with as high a voltage and as low a current as possible. The lower current will not reduce the drop in the electrode, as was shown above, if the electrodes are correctly designed, as it will merely reduce the relation of the cross-section of the electrode to its length. The increased efficiency is due only to the higher voltage.

It seems, therefore, that it cannot be said that the minimum electrode loss is or is not identical with the maximum furnace efficiency if the latter refers to the electrode loss only, because there is no theoretical maximum furnace efficiency, as the furnace voltage may theoretically be increased indefinitely. If the total furnace voltage is fixed, the electrode efficiency is fixed thereby, because the drop in the electrode is a constant. No complicated formulas are required for this; in fact, the formula for the electrode efficiency in per cent is simply

$$\frac{E - 2e}{E} \qquad (4)$$

in which E is the total voltage of the furnace and e the constant drop in each electrode.

There are, of course, numerous practical considerations which may make it impracticable to adopt the theoretically perfect design; but this does not concern the present discussion, which is intended to show what the ultimate conditions are which should be reached if practicable and beyond which it is not possible to go.

Philadelphia, Pa.

A New Refractory Material.

By Prof. Jos. W. Richards.

"Moler" is the local name for a foliated diatomaceous deposit found in the argillaceous eocene deposits in Jutland, northern Denmark, particularly in Mors, Fur and at Silstrup and Ertbolle on the Lim Fjord. Up until recently no use has been found for this material.

Mr. G. A. Heyermann, director of the Royal Polytechnic Institute of Copenhagen tried to use it in the mixture for sand-lime bricks, but found it unadapted to this use. The Clay Laboratory of the Danish States Testing Laboratory has, however, been successful in producing bricks from mixtures of clay and moler in various proportions, and from moler alone, with very interesting results, particularly as concerns the properties of these bricks.

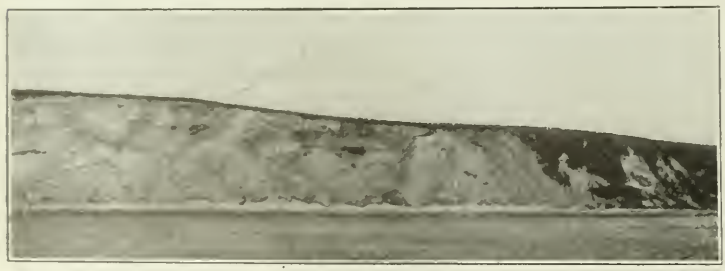


FIG. 1.—CLIFF OF MOLER DEPOSITS.

In the first tests, moler was mixed with 25, 50 and 75 per cent of marl, and with 25 and 50 per cent of red clay; afterwards bricks were burnt from moler alone. Contrary to expectations, moler alone burnt to a fine red brick, very firm and light, and of such toughness that a nail could be driven through without cracking it. The specific gravity of these bricks was about 1, and their strength about that of common bricks.

These results were so encouraging that the "Skrikes Institution" made a grant of 1000 kroner to investigate the possibility of founding thereupon a new industry. The chief engineer of the Clay Laboratory, Mr. Fischer-Moeller, inspected the moler deposits in company with Captain Loof, of Hobro, and Dr. V. Madsen, State Geologist, and succeeded in finding a fine bed of the material at Ejersley, provice of Mors.

FIG. 2.—MOLER BRICK FURNACE.

This is exposed as a cliff 16 m to 20 m high, the white moler being in corrugated strata interspersed with dark stripes of volcanic ash (Fig. 1). The moler was separated from the volcanic ash, and Captain Loof burnt a quantity of it into bricks in his brick-kilns at Vindo, near Hobro.

Various methods of molding, drying and burning were tried, and bricks produced with specific gravity of 0.87 to 1.13 (hardest burnt), and crushing strength 86 to 230 kg per square centimeter (1230 lb. to 3290 lb. per square inch). In all cases their power of absorbing water was considerable, up to 50 per cent of their weight. Their particular properties are their great strength in proportion to their lightness and the heat insulating quality. They are suitable for partitions, floor constructions, arches of every form. They are not suitable for outside use, because of their porosity and absorption of water.

As a refractory they are, however, a most promising material. Their porosity makes their heat conductivity unusually low, and it remained only to test their behavior under strong heat. In the Eastern Gas Works, Mr. Irminger constructed the arches above the retorts of them; at the poor house, Sundholm

Copenhagen, the chief engineer used them for the masonry of steam boilers. In both cases they resisted the heat satisfactorily.

The Frederiksholm Brick & Limeworks Company, Ltd., had the Clay Laboratory conduct some careful experiments to determine their refractoriness. For this purpose, a small vertical shaft (Figs. 2, 3 and 4) was constructed 1.5 m (5 ft.) high,

FIG. 3.—MOLER BRICK FURNACE

1 m square, and with walls one brick (6 in.) thick. The interior was heated by six large gas burners, burning 1200 cu. ft. of gas per hour. The temperatures were measured by Le Chatelier thermo-electric couples placed in iron tubes built into the walls. Temperatures up to 1100° C. were thus recorded; parts of the walls were undoubtedly hotter than this. The results of this test were to prove the complete durability of the moler bricks at these temperatures, the faces exposed to the greatest heat were somewhat vitrified.

Tests at higher temperatures are lacking, as are also exact data on the heat insulating properties, but it is definitely stated that the heat conductivity is phenomenally low

Assuming the reliability of these statements, we have here a most excellent refractory material for intermediate use, as a heat insulator, in the walls of furnaces, as courses between the refractory lining brick and the ordinary outside brick. The low heat conductivity should reduce greatly the heat losses through such composite walls. Its use for electric furnaces, outside of the carbon or magnesite lining, and inside the iron shell, should be highly advantageous.

The manufacture of these bricks is now in the hands of the Frederickshoim Brickworks, Copenhagen, Denmark, from whom they may be obtained commercially. The Fredricksberg Tramway Company, at their new electric power station at Finsensvej, have used 40,000 of them in setting their boilers, also, because of their heat insulating properties, for the masonry of "economizers," and, because of their lightness, for lining a large high horizontal flue.

The above data are taken from a recent report of the Danish State Testing Laboratory, which, under the title "On the Development of Testing of Materials in the North," was presented to the members of the Fifth International Congress for Testing Materials, recently held in Copenhagen

Metal Statistics.

We have received, through the courtesy of the Metallurgical Company of America, the fifteenth annual issue of the "Comparative Statistics of Lead, Copper, Spelter, Tin, Aluminum, Nickel, Quicksilver and Silver," compiled by the Metallgesellschaft, the Metallurgische Gesellschaft A. G., and the Berg-und Metallbank, A. G. (Frankfort-on-Main, July, 1909).

The world's production of lead, copper, spelter and tin, in metric tons, during the last three years is given as follows:

	1906	1907	1908
		in metric tons	
Lead	973,100	984,300	1,052,500
Copper	717,800	703,000	738,900
Spelter	702,000	738,400	722,100
Tin	98,800	97,700	106,500

The average yearly increase in production for the last 10 years was 2.7 per cent for lead, 4.5 per cent for copper, 4.0 per cent for spelter, and 3.9 per cent for tin.

The consumption in metric tons in 1908 in the four principal countries was as follows:

	U. S.	Germany	Great Britain	France
Lead	321,000	211,300	228,800	103,000
Copper	210,600	180,700	128,900	73,900
Spelter	188,300	183,200	138,500	78,000
Tin	32,800	10,700	9,000	7,600

The average yearly prices for all these metals have reached in 1908 a level below that of the average for the last ten years, though it must be borne in mind that the latter average includes the boom prices of 1906 and 1907. Including the year 1908 we have the results here given.

	Average price for ten years	Average price for twenty years
Lead	£14 5 11	£12 12
Copper	68 16 4½	58 4 3
Spelter	22 5½	20 9 10
Tin	137 17 10	108 2

The influence of prices in 1908 upon the earnings of purely

FIG. 4.—MOLER BRICK

mining and combined mining and smelting enterprises is very evident, the falling off in the profits of these concerns having been in almost all cases serious. The purely smelting concerns also, whose business year does not coincide with the calendar year, and which therefore were still to some extent affected by the violent fluctuations of the year 1907, suffered to a considerable extent. In this connection, there was another

factor which was particularly prejudicial, viz: the fact that in the past year also prices of fuel and raw materials in many countries had not yet properly adjusted themselves to the altered economic conditions.

Then follow detailed notes on lead, copper, spelter, and tin and—as a new feature of these statistics—a statement of the share capital of important metal-producing stock companies, together with their highest and lowest share quotations for the last three years.

The main part of the book is taken up as usual by comparative statistical tables on production, consumption, and prices of aluminum, lead, copper, nickel, mercury, silver, zinc, and tin. It is, of course, impossible to abstract these tables. It is unnecessary to emphasize the long established thoroughness and reliability of these well-known yearly statistics.

Observations Upon the Alloys of Iron and Manganese.

By Chas. F. Burgess and James Aston.

With the development of modern steel-making processes manganese may be said to be present in practically all steels. As the universal cure-all, the tonic of the metallurgist, it is added as a deoxidizer and in sufficient excess (up to about 1 per cent) to minimize the effect of the sulphur present. In larger quantities, running to a percentage of 10 or upward, we find it in various alloy steels for the special properties conferred.

As far as the resulting mechanical properties are concerned, we are justified in using considerable amounts of manganese, since the effect is beneficial, rather than otherwise. But how about its use in the large quantities of steel employed for its purely electrical features, in the form of sheet and also as castings?

In connection with our work upon the properties of electro-

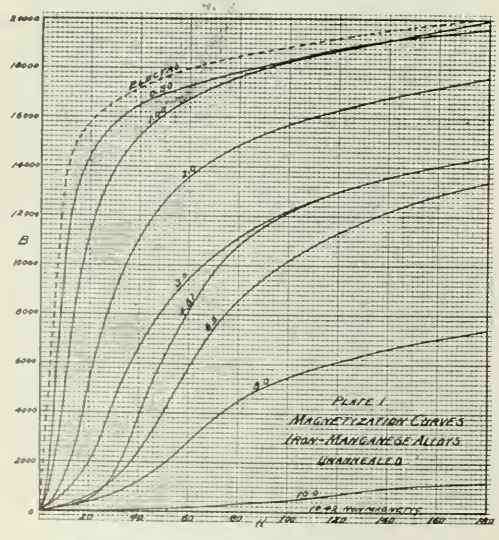


FIG. 1.—MAGNETIZATION CURVES, IRON-MANGANESE, UNANNEALED.

lytic iron and its alloys, carried out under a grant of the Carnegie Institution, of Washington, we have observed certain peculiarities in the magnetic behavior of the iron-manganese alloys which may be of interest. The primary constituent in the preparation of these alloys is iron of high purity, gotten by double electrodeposition from Swedish iron anode bars. The character of this material may be seen in the following table:

	Swedish Anode	Double refined as deposited	Electrolytic fused and forged
C	0.260	0.012	0.047
S	0.007	None	0.005
Si	0.109	0.013	0.062
P	0.007	0.004	0.016
Mn	0.021	None	None
Iron (by difference		99.971)	

In view of the very small amount of impurities present in the electrolytic iron, the properties of the alloys prepared may be considered to be due solely to the presence of the alloying elements. The alloys were prepared by melting the electrolytic

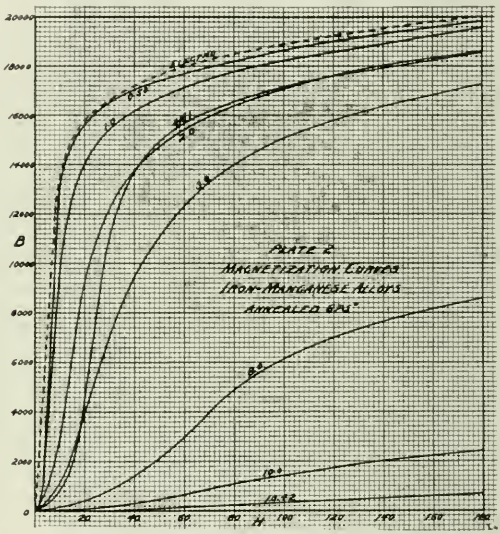


FIG. 2.—MAGNETIZATION CURVES, IRON-MANGANESE, ANNEALED 675°.

iron, together with the other desired element, in a covered magnesia-lined graphite crucible, bedded in an electric resistor furnace. The ingot, about 1 lb. in weight, was then forged into a rod under a steam hammer. Two bars were obtained for tensile strength tests and one for the magnetic measurements.

The following alloys with manganese were tested:

Bar	% Managese Added	Analysis
123H	0.50	0.505
170A	1.0	
170B	2.0	
170C	3.0	
144V	3.5	
123I	4.0	4.514
170D	6.0	
170E	8.0	
170F	10.0	
123J	11.9	10.419

Analyses have been made upon but three of the samples as indicated above. However, in these three instances, the intended and actual percentages are in reasonably close agreement, and it may be assumed, especially since manganese and iron are closely allied, that the bars not analyzed have a manganese content approximately as indicated by the added percentage.

All of the alloys forged readily at normal heats. Bars with 0.50 per cent and 1 per cent manganese were soft and machined easily with ordinary lathe tools, but it was somewhat difficult because of their hardness. Above 3 per cent of manganese it was necessary to resort to grinding to work the forged pieces into finished test bars.

Tensile strength tests were made on only three of the bars, the results being as follows:

Bar	%MN	Stress per sq. in. Elas. Limit	Ultimate	Per cent Red. Area	Elongation
123H	0.505	45200	57300	76.6	31
123I	4.514	196000	196000	0	0
123J	10.419	64500	88800	4.1	6

These figures can hardly be used as a basis for discussion, except that they bear out the general conclusion obtained in tests of commercial materials. Addition of 0.50 per cent of manganese has caused but little variation from the results with pure iron; at 4.51 per cent Mn we are in the region of great strength and brittleness, as is indicated by the high ultimate strength and the negligible elongation. At the highest percentage of manganese (10.42) the material still has high ultimate strength, but a greater toughness, shown by the elongation of 6 per cent.

TABLE I.—DATA OF MAGNETIC TESTS.

BAR	Comp %	H=10				H=20				H=50				H=100			
		Unann.	Ann. 675°	Ann. 1000°	Quench. 900°	Unann.	Ann. 675°	Ann. 1000°	Quench 900°	Unann.	Ann. 675°	Ann 1000°	Quench 900°	Unann.	Ann. 675°	Ann. 1000°	Quench 900°
123H	0.50	9,850	13 000	11,300	10,700	14,300	15,000	14,550	14,400	16,950	17,400	16,600	16,850	18,300	18,400	17,900	18 150
170A	1.0	4,850	9,700	5,400	.....	11,000	14,000	11,200		16,100	16 700	15,800		18,200	18,000	17 800	
170B	2.0	1,350	3,100	1,100	.....	5,100	9,200	3,750		12,500	14,700	11,150		15,700	16,700	15,150	
170C	3.0	650	1,150	900	.....	1,900	4,000	3,150		8,150	11,050	10,750		12,200	14,550	14,050	
144V	3.5	1,100	850	950	.....	3,500	2,700	3,050		10,600	10,150	9,800		13,500	13 600	13,550	
123I	4 51	150	800	500	900	500	4,600	1,200	3 350	6,150	14,900	5,250	11 700	12,100	16,800	10,600	16,400
170D	6.0	200	.....	.....	.....	600	.....	.....		3,950				10,150			
170E	8.0	150	150	50	.....	350	400	100		1,900	2,100	750		5 450	6,100	1,750	
170F	10.0	0	50	150	0	0	100	200		100	450	450		500	1 400	1,400	.....
123J	10 42	0	0	0	0	0	0	0	0	0	50	50	150	0	300	300	500

The magnetic tests were made upon an Esterline permeameter, under four conditions of heat treatment, viz.: as forged, after annealing at 675° C., after annealing at 1000° C., and after quenching at 900° C. All results are compared to a standard bar of forged electrolytic iron in its unannealed state. The curve for this sample is indicated by a dotted line, and material of a quality equal to this standard is of very high grade.

The magnetic tests data are indicated in Tables I and II and Plates 1, 2, 3 and 4. In the unannealed condition the alloys show a successive deterioration in permeability with increasing manganese content, until at the maximum percentage, 10.42 (123J), the bar is non-magnetic. Bars 123H and 170A, with 0.50 per cent and 1 per cent, are not greatly inferior to the standard, this being especially true of 123H, and the discrepancy is still less after the annealing at 675°.

This annealing has resulted in a marked betterment of magnetic quality for all bars, the increase being most striking for bar 123I (4.51 per cent Mn). Bar 123J (10.42 Mn) becomes slightly magnetic and remains so throughout the succeeding tests, but it may be regarded as a non-magnetic alloy.

The second annealing at the higher temperature of 1000° has caused a considerable decrease of permeability of all bars and for all values of the magnetizing force; in fact, the materials are in practically the same condition as when raw forged. This decrease is most striking for the 4.51 per cent Mn bar, as was the previous increase.

But three of the bars have been tested in the quenched condition, and the only important feature is the great improvement in bar 123I (4.51 Mn), which has been restored to its best condition, as obtained after the first annealing at 675°. Whether this is due to any direct effect of quenching or to the reheating at the lower temperature of 900° is problematical.

TABLE II
COERCIVE FORCE AND RETENTIVITY. H(max) = 200

BAR	Comp'd%	COERCIVE FORCE				RETENTIVITY			
		Unann	Ann 675°	Ann 1000°	Quench 900°	Unann	Ann. 675°	Ann 1 00	Quench 900°
123H	0.50	6 5	5 7	4 5	4 8	11 000	12 500	9,700	10,100
170A	1.0	9 6	6 9	7 0		10 80	14,700	9,0 0	
170B	2.0	19.2	12.5	16 0		10 50	11 [illegible]	8 80	
170C	3.0	28.2	21 0	24 0		8 50	9,8	9 60	
144V	3.5	20 8	28 0	24 5		[illegible],600	10 600	8,9	
123I	4.51	41.8	23.0	45 2	23 9	8,600	15,000	8 [illegible]	12,900
170D	6.0	50.8	.....			9,200			
170E	8.0	58.7	57.5	65 0	.....	5,200	6,[illegible]0	2,000	
170F	10.0	90.1	70 7	80 0		1,100	1,800	1,900	
123J	10.42	Non.	103.0	121.0	8 5	Non	400	500	800

The values of coercive force and retentivity, as indicated in Table II, follow most closely the fluctuations pointed out in the discussion above. The retentivities increase as a result of annealing at 675°, decrease at the high heating of 1000°, and again increase with the quenching at 900°. For bar 123II (0.50 Mn) the coercive forces become less with each annealing, and there is little change after quenching. But for other bars the values of coercive force decrease with annealing at 675°, increase after heating to 1000°, and again become less after quenching at 900°.

The deductions to be drawn from these tests may have an important bearing upon certain problems in the manufacture of steel for electrical purposes, particularly steel castings. It is well known that there is a decided lack of uniformity in this material, and experience shows that numerous concerns have difficulty in making castings of this class, although for other purposes their product is of high grade. Our results indicate a falling off in the magnetic quality of the alloys with an increase of manganese. For a percentage of 0.50 the permeability is but slightly less than that of the standard electrolytic sample. At 1 per cent Mn the quality has become appreciably less, and on further increase to 2 per cent the alloy is of comparatively low grade.

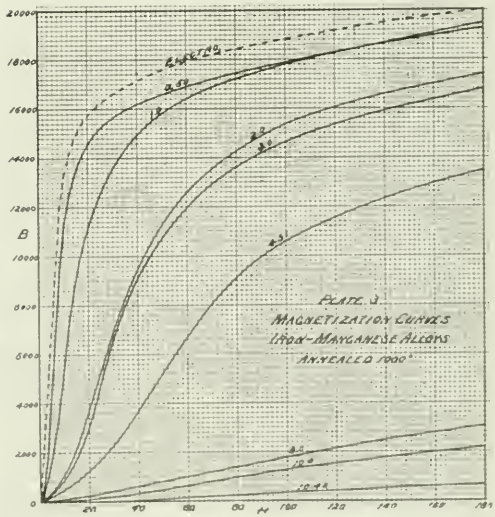


FIG. 3.—MAGNETIZATION CURVES, IRON MANGANESE, ANNEALED 1000°

If this be true in the above series, might it not be that in commercial material where the carbon and other elements are by no means negligible that the limits of manganese content are even more closely drawn than our results indicate, and are thus very often overstepped, particularly in foundry practice? It is beyond question that any addition of manganese is a detriment. Why, therefore, in steels for electrical work, where

in general strength is of secondary consideration, adhere to manganese additions? Cannot the sulphur be reduced to the lowest possible limits, and cannot the oxidation be taken care of by addition of an element such as silicon, an excess of which has a beneficial effect? Or will not the electric refining furnace solve the whole problem?

But of greater bearing than the actual manganese content is the marked susceptibility of these alloys to variations in the

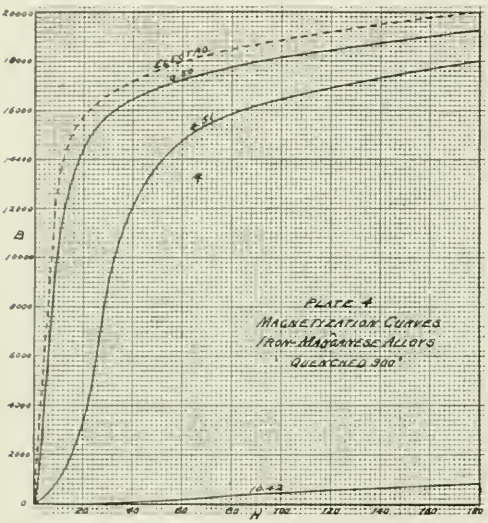


FIG. 4.—MAGNETIZATION CURVES, IRON-MANGANESE, QUENCHED 900°.

heat treatment. Judicious annealing at low temperatures may be of greatest benefit to material which would otherwise be condemned, while an overheating may spoil a good material or nullify the effect of heat treatment. This factor may be relevant in commercial work, where very often castings are not annealed at all; and in other cases the annealing is done without skilled supervision or without the check of a pyrometer. Or, even if carefully conducted, the temperatures used, while suitable for general work, may be too high for the electrical steels.

Chemical Engineering Laboratories,
University of Wisconsin.

The "Pinch Effect" in Electric Furnaces of the Induction Type.

By Joh. Harden, E. E.

Carl Hering and E. F. Northrup* have on various occasions dealt with the "pinch effect." It might, therefore, be of interest to electrochemists to obtain a few practical figures relating to this matter.

It is, of course, very difficult to give the actual conditions under which the phenomena occurred, because, as Mr. Hering points out, so many factors will influence its appearance and the brevity of its duration tends to make an exact and reliable observation almost impossible. There is, therefore, little wonder if the practical results do not correspond closely with the theoretical formulas given by Hering and Northrup, nor is it, therefore, to be concluded that these are incorrect or misleading. On the contrary, the figures given here rather support these theories.

*Electrochem. and Met. Industry, Vol. V, p. 223; VI, p. 383; VII, p. 266, 271, 369.

The data referred to here was obtained in a 60-kw induction furnace of the Kjellin type, designed and operated by the Gröndal-Kjellin Company, of London; this furnace is now erected at the Sheffield University, in the Department for Applied Science.

The furnace has a total capacity of about 3 cwt. (300 lb.) and is operated with single-phase alternating current, 55 cycles to 60 cycles.

The "pinch effect" was observed when melting scrap and pig iron preparatory to a steel-melting test. The approximate section of the bath was, when the phenomena occurred, as follows: width, 1¾ in.; depth, 2½ in., hence cross-section 4.375 sq. in. The bath was nearly rectangular, the bottom being somewhat narrower than the top.

The metal contained about 2 per cent carbon, and the temperature was estimated at about 1400° C.

The primary coil consisted of 23 turns; the primary current was 220 amp. If we assume that the leakage field, etc., consumed about 10 per cent of the ampere-turns, which on other occasions was found to be practically correct, we find that the secondary current was 4450 amp. The current density was consequently about 1020 amp. per square inch, which might seem rather low, but if we consider that the resistance of the iron is increased with more than 0.5 per cent for every degree above red heat, we find that this density is in reality not so surprisingly low.

The level of the bath commenced to recess on a certain point, showing a cavity of about 5/8 in. deep. Curiously enough this occurred on several occasions on the same spot; when the lining was examined after the furnace had cooled down, it was found that a small piece of cinder, fused to the wall of the lining, was the cause of a slight distortion of the bath section on this spot and this undoubtedly was the cause of the contraction on this particular place.

As the temperature rose to a bright white heat, the agitation became more violent, until suddenly a complete rupture took place, followed by a loud report and a severe shaking of the furnace body. A strong flash was at the same time observed, the level of the metal rose to about 1½ in. above the average on both sides of the rupture and the metal rushed down these hills with great rapidity. The bath closed again immediately after the rupture, but as soon as the surfaces were touching they were again separated before full contact was obtained, causing a rapid clatter, but of less violence than the first.

If allowed to go on, the metal soon froze, because of the oxidation caused by the flashing, which in a short time prevented further contact. In that case it was very difficult to again establish the contact and resume the melt; in fact, as the phenomenon once occurred under a strong slag blanket, which was used for refining purposes, it was found impossible to finish the melt and the charge had to be broken out. The instruments were hunting violently during the occurrence, jumping between maximum and zero so that no readings could be taken.

It was soon found, however, that this annoying feature could be effectively avoided in the case of iron melting; if, as soon as the first tendency to recessing appeared in the bath the power was lowered, say, 5 per cent to 8 per cent, and a handful of small pieces of pig iron, of about the size of a pea, which was kept ready for the purpose, was thrown into the cavity the temperature of the metal was so much lowered on the dangerous spot that a rupture was avoided. By carefully continued charging of iron it was then always possible to reach a point when rupture would no more take place with the power available.

If the bath was filled to its normal depth of about 6 in. it was not possible to obtain the "pinch effect" with the total power available of 63 kw. It might in this connection be of interest to make a few remarks about the general agitation of the bath, due to the combined effect of the heat and the magnetic influence.

In the first place, there is a kind of rolling motion, i.e., a rotation of the mass of metal around the longitudinal axis of the bath. This is caused, in all probability, to a great extent by the so-called "Thomson effect," and which is very prominent in an ordinary "constant-current" transformer. The stray field has a tendency of lifting the metal out of the hearth and as the charge is liquid a rolling action is thus produced.

This can, to a certain extent, be modified by shifting the position of the primary coil, but as a good mixing of the bath is effected by this rolling, it is not desired to check it too much. In a large furnace, however, the agitation may be so excessive as to shorten the life of the lining, if special precautions are not taken.

This action is accelerated by the effect of the temperature; the inner circumference of the bath is shorter than the outer, and also its radiation surface is smaller, hence the local heating is somewhat greater in this portion of the bath, the more so as owing to the shorter length of the inner circumference the electric resistance is also smaller and the current density, therefore, perhaps somewhat greater; this may, however, to a certain extent, be counterbalanced by the distribution of current due to the electro-magnetic repulsion between the primary and secondary.

This latter is causing another disturbance of the bath level; the secondary conductor, formed by the molten metal ring, has a tendency to increase its diameter owing to the mutual action of the fields set up by the primary and secondary currents. The result is that the metal is thrown toward the outer wall of the hearth, causing the level on the outer circumference of the bath to rise, sometimes as much as 8 per cent to 10 per cent. This is especially the case when dealing with metals of lower melting point than that of iron, because the high fluidity of well-heated liquid steel makes it more subject to the influence of the rising effect on the inner wall caused by the temperature action.

This phenomenon may very often have annoying consequences. When the lining has to be repaired it is always found that the crucible wall is very much more attacked on the inner circumference, just about the level of the bath, than compared with the outer circumference.

This is due to the slag which accumulates along this line, because, as it has a much higher resistance than the molten metal, practically no current passes through it and it, therefore, slides down the inwardly inclining surface of the steel toward the inner crucible wall. It is also only subjected to the ascending action of the local heat mentioned, and, therefore, is thrown up on the side of the lining, fluxing with the magnesite and thus causing the annoyance. Fortunately, this can be avoided by using a neutral slag, which is quite permissible, as no refining is generally required in these furnaces.

Finally, a third class of rotation can also be observed in the bath. This is shown by the fact that if a lump of some material with a higher melting point, such as a piece of ferrochrome, is thrown in at the front of the hearth, the lump will soon be found to have traveled round to the back of the furnace opposite the spout, and may even make a complete revolution before it is finally absorbed. This shows that the molten ring is also rotating around the primary coil in the direction of the longitudinal axis of the bath.

This rotation is rather slow; in a 1½-ton furnace, operated with single-phase alternating current of 16 cycles, the velocity is about 1 ft. to 2 ft. per second. It is always moving in one and the same direction in the same furnace, its cause may be somewhat difficult to explain without carrying us too far, but it is possible that it is analagous to the effect in a synchronous motor, or else similar to that occurring in a rotary converter, which is started from the alternating-current side, while the armature is short-circuited. At any rate, this rotation is highly beneficial for the proper mixing of the metal; it is especially prominent in a three-phase combined furnace of the Roechling-Rodenhauser type, where the agitation is so strong sometimes that steps must be taken to check it.

Stassano employs, as is well known, a mechanical contrivance to rotate the whole furnace so as to obtain a similar mixing effect.

The pinch effect was further observed when dealing with copper and brass. The melting of the former was entirely frustrated in an ordinary magnesite lining. The hearth was first heated by means of a welded steel ring; after this had been removed, it was sought to establish a permanent bath by pouring in molten copper from a graphite crucible heated in a coke fire. A quantity of graduated copper was kept ready for replenishing. Before the bath was formed, however, the ring snapped off and the metal gradually froze. The primary current was 400 amp; the secondary calculated to be 8280 amp and the current density about 1650 amp per square inch. It may, however, have been a good deal higher locally, owing to the very strong agitation of the metal before snapping.

I might mention, however, that I have seen copper being treated, though with difficulty, in another furnace, but here the crucible, though made of fireclay, had a depth of about 8 in. or 9 in., while the average width was only about 7½ in. Here the pinch effect could not so easily take place, but the difficulty in handling a bath of this shape made the furnace practically useless, besides the heavy heat losses by radiation.

The next trial with a view to studying the pinch effect was made with brass. This was more successful, as it was quite possible to obtain a liquid bath, but the pinch effect was readily obtained when forcing the current.

The bath section was 5½ in. x 1¾ in., or about 9.5 sq. in. The "pinching" commenced under violent agitation of the whole bath, i.e., with an approximated density of only 530 amp per square inch. It is quite likely, however, that the density was again much greater at the moment of the "pinching" owing to the strong agitation of the bath, otherwise it could hardly be accounted for.

The zinc fumes which were liberated when the rupture took place caused some difficulty in re-establishing good contact; however, by throwing in small pieces of scrap brass and slightly lowering the current the pinch effect could be tolerably avoided.

In the meantime a very effective arrangement has been devised by the writer whereby all the disturbing effect of this phenomenon is completely avoided; it is even possible to treat copper by this means without the slightest difficulty and with a comparatively shallow bath. Owing to a pending patent application the nature of the device cannot for the present be divulged, however.

In a larger induction furnace with a charge of 2 tons to 3 tons the pinch effect is very rarely observed, except if the melting is very much forced during the period of recharging, in which case it may occur. The rupture, however, is of little importance, because the heat capacity of the remaining bath is sufficiently large to procure a good contact should a rupture take place.

Again, in the case of the combined furnace of the Roechling-Rodenhauser type, the pinch effect has not been observed in regular operation as far as is known. It is also very unlikely that this should be the case, because, in the first place, the furnace is practically always started by pouring in a charge of molten metal, which at once fills up the channels to the normal level. At the beginning, before the furnace is properly heated, all the heat will be generated by the inductive current in the channels only, but in a very short time the coating on the cast-steel plates will become conductive and as soon as this takes place the channels are relieved as from one-third to over one-half of the total power will pass through the bath in this way. a contraction of the middle portion of the bath is, of course, impossible because, apart from the fact that the large section of metal prevents such a course, the heating is in this part of the furnace converted from the said coating and not generated by the current directly in the steel.

This fact also explains why the word "electrodes" for the

cast-steel plates would be somewhat misleading; these plates are only part of the conductors by means of which the auxiliary secondary current is conveyed from the copper cables to the conductors of second class formed by the magnesite coating attached to them. This coating will be heated by the passing of the current through the refractory mass, exactly in the same manner as a Nernst glower is heated; it seems incongruous to call the holders of a Nernst glower "electrodes" as this term is generally associated with an arc or an electrolyte. The current density in the bath, conveyed to it in this way, is much too low to cause any appreciable amount of heat.

London, September, 1909.

A Theoretical Study of the Efficiency of Direct Heat Dryers.

By John Jermain Porter.

By direct-heat dryers are meant those dryers in which the gases of combustion come into direct contact with the material to be dried, and form the vehicle which removes the moisture. The temperature of these gases is necessarily a function of the quantity of excess air admitted to the burning fuel.

All direct-heat drying operations may be divided into three classes:

1. Those in which the heated gases which do the drying and the moist material to be dried move continuously and in the same direction through the apparatus. This class we may term parallel current dryers.

2. Those in which the heated gases and the moist material move continuously through the apparatus, but in opposite directions. These are countercurrent dryers.

3. Those in which the operation is not continuous, the water or moist material being present in definite quantity and the hot gases being passed over it until it is all evaporated. This may be called the intermittent form of dryer.

Each of these forms is a separate problem when it comes to deriving an expression for the amount of evaporation and in determining the conditions of maximum efficiency.

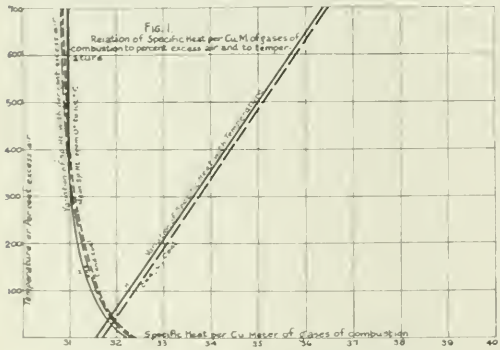


Fig. 1.
Relation of Specific heat per Cu.M. of gases of combustion to percent excess air and to temperature
Temperature of Air and excess air
Specific Heat per Cu Meter of gases of combustion

Fig. 1.—Relation of specific heat per cubic meter of gases of combustion to per cent excess air and to temperature.

In all of the calculations of this paper the following symbols will be used:

- H Heat of combustion per unit of fuel in kilogram calories, water uncondensed.
- M Kilos of water formed by the combustion of one unit of fuel.
- M_1 Kilos of water evaporated from M per unit of fuel.
- W Kilos of water added to dryer per unit of fuel.
- W_1 Kilos of water evaporated from W per unit of fuel.
- T Total kilos of water evaporated per unit of fuel, $= W_1 + M_1$.
- D Kilos of solid substance added to dryer per unit of fuel.
- V Cubic meters of gases of combustion, under standard conditions, per unit of fuel.
- V_1 Cubic meters of water vapor, under standard conditions, resulting from the combustion of one unit of fuel.
- s_1 Specific heat of gases of combustion.
- s_2 Specific heat of solid substance added to dryer.
- t Temperature at which gaseous products leave dryer.
- t_1 Temperature of gases of combustion on entering dryer.
- t_2 Temperature of water and solid added to dryer.
- t_3 Temperature at which solid and excess of water leave dryer.

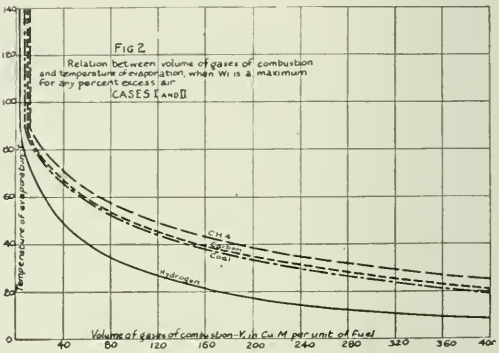


Fig 2
Relation between volume of gases of combustion and temperature of evaporation, when W1 is a maximum for any percent excess air
CASES I and II
Temperature of evaporation
Hydrogen
Volume of gases of combustion V1 in Cu M per unit of Fuel

Fig. 2.—Relation between volume of gases of combustion and temperature of evaporation, when W_1 is a maximum for any per cent excess air.

- pp Partial pressure of water vapor in gaseous products leaving dryer.
- Lt Latent heat of evaporation of water at any temperature t.
- n Number of units of fuel burned per minute.
- m Total number of minutes of drying (in case III).
- m_1 Number of minutes in first phase, heating up stage (case III).
- m_2 Number of minutes in second phase, evaporating stage (case III).
- C Kilogram calories of heat lost through radiation and conduction per unit of fuel burned.

I. The Parallel Current Dryer.

If we assume that a sufficiently intimate contact of gases and substance to be dried is obtained, then there are two self-evident facts which may be stated as axioms and which furnish a basis on which to work. First, all products leave the dryer at the same temperature. Second, as long as water is in excess (i.e., as long as liquid water escapes from the discharge end of the dryer) the gases escaping will be saturated with water vapor.

Since the heat in the incoming substances is equal to the heat in outgoing products plus the heat lost by radiation and conduction, we have, using metric units:

$$H + 606.5\,M + Wt_2 + Dt_2 s_2 = (V - V_1)\,ts_1 + Dts_2 + (W - W_1)\,t + (M - M_1)\,t + W_1\,(606.5 + 0.305\,t) + M_1\,(606.5 + 0.305\,t) + C \quad (1)$$

This is the general equation which applies to every possible condition.

As an additional condition of evaporation it is necessary that the volume of gases must be sufficient to carry off the water vapor formed, or the volume times the partial pressure must be equal to or greater than the volume of water vapor present. Therefore:

$$T = \text{or} > \left(\frac{V - V_1}{1 - pp}\,pp\ 0.81\right) \quad (2)$$

As an aid in clearing up our ideas on this subject let us for

a time look at it from another standpoint, first reducing our dryer to the simplest possible conception.

First, we will render the dryer independent of time by conceiving it a simple box, in which we introduce a weight of water W, at an initial temperature t_2, and then a volume of gas V, containing H heat units. The box is then closed up and shaken until the contents reach a state of equilibrium at some final temperature t. This is essentially the same thing as the parallel current dryer, since by repeating this operation each

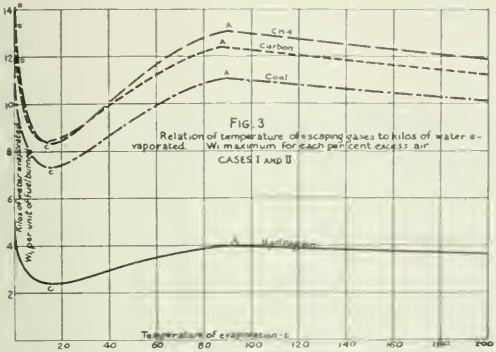


FIG. 3.—RELATION OF TEMPERATURE OF ESCAPING GASES TO KILOS OF WATER EVAPORATED. W_1 MAXIMUM FOR EACH PER CENT EXCESS AIR.

interval of time and making the intervals infinitely small we have the continuous process.

Now, keeping V constant in our box, but varying W, let us see what happens.

First, with W infinitely large it is evident that there can be no rise in temperature above t_2, or $t = t_2$, and if the gas contains moisture (as from the combustion of hydrogen containing fuels) there will not only be no evaporation, but there will be precipitation, or W_1 the water evaporated, will be a minus quantity.

As we make W less, t gradually rises above t_2, and the precipitation, or value of $-W_1$, decreases until finally, at some certain value of W, t reaches the dew point of the gas, and there is neither precipitation nor evaporation, or $W_1 = O$. Decreasing W still more t continues to rise, and as t is now above the dew point of the gas some evaporation takes place. The amount, however, is given by the equation

$$W_1 = \frac{V pp - V_1}{1 - pp} 0.81,$$

and much of the heat supplied in the gas is wasted as sensible heat in the excess water, as given by the third term of equation (1).

Finally, a point is reached at which W is just equal to W_1 and at the same time the gases pass out saturated; t at this point is evidently the temperature of maximum efficiency, or T and W_1 equal a maximum, since in order to get a higher temperature we must continue to reduce W, and, hence, also W_1 and T. It is also evident that above this temperature the gases are no longer saturated with moisture.

Evidently now we have three variables upon which evaporation depends—V, W, and t; t is dependent on both V and W, and if one of these be held a constant, is directly a function of the other.

For the maximum efficiency of evaporation (T = a maximum) there are two conditions to be fulfilled; first, $W = W_1$; i.e., there must be no excess water to carry out sensible heat from the dryer. Second, V should have the smallest possible value, so as to avoid carrying out more sensible heat than is necessary in the gases.

Now, the maximum for the value of V is limited by equation (2), hence, for the maximum efficiency this may be written as an equality and we may then substitute (2) in (1) and get an expression giving V in terms of t when W_1 and T are at the maximum for any t or vice versa.

Doing this and remembering that T equals $W_1 + M_1$, we get

$$H + 606.5\,M + Wt_2 + Dt_2 s_2 = (V - V_1)\,ts_1 + Dts_2 + (W - W_1)\,t - (M - M_1)\,t + (606.5 + 0.305\,t)\left(\frac{V - V_1}{1 - pp}\right) pp\,0.81 + C \qquad (3)$$

This equation does not, of course, hold for temperatures above a certain limit. As t rises V must become less in order that the gases may still be saturated. Now, when V is reduced to the minimum resulting when the fuel is burned with the theoretical amount of air, if t is still raised the gases will not be saturated, (2) will not be an equality, and (3) will not hold true. Evidently, then, we have (3) giving us the relation between W, V, and t for maximum evaporative efficiency up to some certain value of t, while above this value of t we must fall back on equation (1), remembering that V in this case is a constant, and equal to that formed when the fuel is burned with the theoretical air.

Finally, it is evident that for the lower range of temperatures where the gases are saturated

$$W_1 = \left(\frac{V - V_1}{1 - pp} pp - V_1\right) 0.81, \text{ which reduces to}$$

$$W_1 = \left(\frac{V pp - V_1}{1 - pp}\right) 0.81. \qquad (4)$$

II. The Counter Current Dryer.

The case of the counter-current dryer is different in that the excess of water or moist material need not pass out at the same temperature as the discharged gases, since they leave at opposite ends of the apparatus. The general equation, therefore, becomes

$$H + 606.5\,M + Wt_2 + Dt_2 s_2 = (V - V_1)\,ts_1 + Dt_3 s_2 + (W - W_1)\,t_2 + (M - M_1)\,t_2 + W_1 (606.5 + 0.305\,t) + M_1 (606.5 + 0.305\,t) + C. \qquad (5)$$

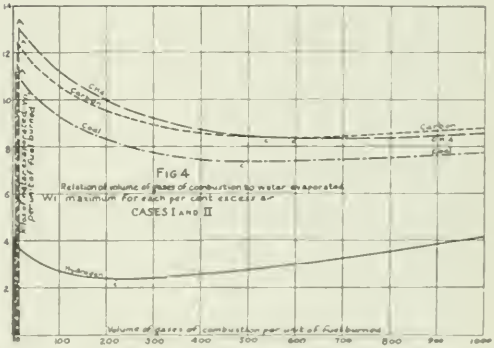


FIG. 4.—RELATION OF VOLUME OF GASES OF COMBUSTION TO WATER EVAPORATED. W_1 MAXIMUM FOR EACH PER CENT EXCESS AIR.

As before we have $T =$ or $> \left(\frac{V - V_1}{1 - pp} pp\,0.81\right)$ (2)

and for T maximum for any t

$$H + 606.5\,M + Wt_2 + Dt_2 s_2 = (V - V_1)\,ts_1 + Dt_3 s_2 + (W - W_1)\,t_2 + (M - M_1)\,t_2 + (606.5 + 0.305\,t)\left(\frac{V - V_1}{1 - pp}\right) pp\,0.81 + C \qquad (6)$$

As before (6) is true up to some certain value of t, above this we must fall back on (5), while below it equation (4) is also true.

III. The Intermittent Dryer.

(t_1 greater than 100° C.)

In order to evaporate a weight W_1 of water we must first raise this water, and the solid D with which it is associated, to the temperature at which evaporation is to take place. During this period the gases will be discharged at a constantly rising temperature, varying from t_2 to t, and equal on the average to $\frac{t-t_2}{2}$. If the gas has a dew point below t_2 the heat absorbed during this period will be

$W(t-t_2)+Ds_2(t-t_2)+V\frac{t}{2}s_1 nm_1+nm_1 C$, where m_1 is the time of this phase.

After W has reached the temperature t evaporation may be assumed to begin (although in reality it has been going on right along) and the heat carried out is equal to $W_1 Lt+Vs_1 tm_2 n+nm_2 C$, where m_2 is the time of this phase.

Our general equation between heat supplied and heat absorbed and carried out then becomes

$$Hnm+Wt_2-Ds_2 t_2=V\frac{t}{2}s_1 nm_1+Dts_2+Wt+W_1 Lt+Vs_1 tnm_2+nmC. \quad (7)$$

But $W=W_1$, therefore $Wt+W_1 Lt=W_1(606.5+0.305\,t)$, and so

$$Hnm+Wt_2+Ds_2 t_2=nVs_1\left(m_1\frac{t}{2}+m_2 t\right)+Dts_2+W_1(606.5+0.305\,t)+nmC. \quad (8)$$

This expression is strictly correct even in case there is a condensation of water from V during the beginning of the operation. In this case the heat evolved by this condensation is later absorbed in the evaporation of the same water. That is, $606.5\,M=M_1 t+M_1 Lt$. It is not considered necessary to combine this equality with equation (8), since in this case M_1 must always equal M. Also, the fact that the gases may be less in volume than V at the beginning of the operation (owing to condensation of part of V_1) is exactly counterbalanced by increase in volume above V later on due to reëvaporation of this water.

It would seem now that as long as there is sufficiently intimate contact between gases and water or moist material that the gases must leave the drying chamber saturated with water

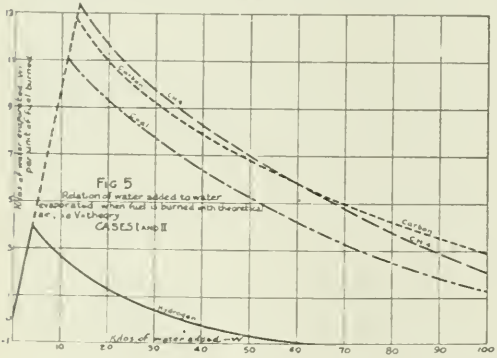


FIG. 5.—RELATION OF WATER ADDED TO WATER EVAPORATED WHEN FUEL IS BURNED WITH THEORETICAL AIR, I.E., V = THEORY.

vapor. This is true during the first part of the heating-up stage, but is not true the latter part nor after equilibrium is reached, simply because the heat contained in a given volume of gases is not sufficient to evaporate enough water to saturate them. This is true even in the special case where the incoming gases are at a temperature below 100° C. and which will receive separate attention later on.

In case III proper, when the temperature of the incoming gases is greater than 100° C. the temperature of evaporation t is, during the second stage of the operation, always equal to 100° C. This seems self-evident, since the water must rise in temperature, as fresh additions of heat are brought in by the incoming gases, until the boiling point is reached, after which absorption of latent heat of evaporation keeps the temperature constant until the water is all vaporized.

Hence, putting $t=100$ in (8) we get as our final equation for this case:

$$Hnm+Wt_2+Ds_2 t_2=50Vns_1(m_1+2m_2)+100Ds_2+637W_1+nmC. \quad (9)$$

Case IIIA. Intermittent Dryer.

(t_1 less than 100° C.)

A special case of the intermittent dryer is found when the

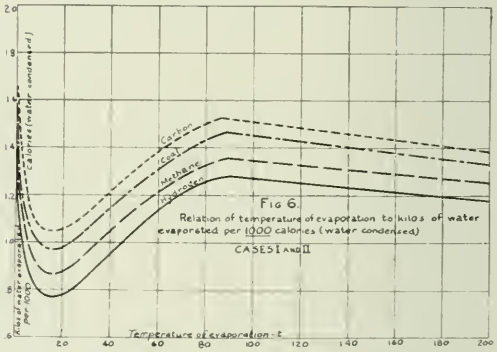


FIG. 6.—RELATION OF TEMPERATURE OF EVAPORATION TO KILOS OF WATER EVAPORATED PER 1000 CALORIES (WATER CONDENSED).

incoming gases are at a temperature of less than 100° C. In this case V is a function of H and t_1 and cannot be considered an independent variable.

$$Vs_1 t_1=H, \text{ or } V=\frac{H}{s_1 t_1} \quad (10)$$

Equation (8) still holds good and substituting (10) in this we get

$$Hnm+Wt_2+Ds_2 t_2=\frac{nH}{t_1}\left(m_1\frac{t}{2}+m_2 t\right)+Dts_2+W_1(606.5+0.305\,t)+nmC. \quad (11)$$

But in this case t will always equal t_1 just as the evaporation is completed; i.e., the temperature will continue to rise first rapidly, then slowly, approaching but never quite reaching t_1 until the last of the water is just evaporated. In other words, we may say $t=t_1$, and $m_1=m$, $m_2=0$. Therefore,

$$Hnm+Wt_2+Dt_2 s_2=\frac{Hnm}{2}+Dt_1 s_2+W_1.(606.5+0.305\frac{t_1}{2})+nmC. \quad (12)$$

The gases are, of course, only saturated during the first part of the operation.

We have now succeeded in deriving formulas for the several systems of drying, by the use of which we may find the amount of water evaporated for any given set of conditions. It remains now to determine the conditions of maximum efficiency, or conditions under which the greatest amount of water is evaporated per unit of fuel burned.

In order to accomplish this we may determine W_1 maximum for each t or V and plotting these a curve will be obtained which will show the efficiency of evaporation at every temperature and, of course, the conditions of maximum efficiency. The same result might also be accomplished by the calculus.

I have worked out these efficiencies on the basis of four fuels,

to wit, hydrogen, methane, carbon and a bituminous coal of analysis

Carbon	70 per cent.
Hydrogen	6 per cent.
Oxygen	12 per cent.
Nitrogen	2 per cent.
Ash	10 per cent.

These fuels were chosen as representative of all classes and as giving the maximum possible range of water in the gases

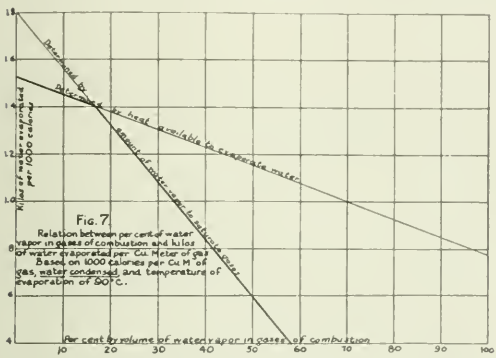

Kilos of water evaporated per 1000 calories
Per cent by volume of water vapor in gases of combustion
Represented by Polygon A
Amount of water vapor in saturated gases
Fig. 7.
Relation between per cent of water vapor in gases of combustion and kilos of water evaporated per Cu. Meter of gas
Based on 1000 calories per Cu M of gas, water condensed and temperature of evaporation of 90°C.

FIG. 7.—RELATION BETWEEN PER CENT OF WATER VAPOR IN GASES OF COMBUSTION AND KILOS OF WATER EVAPORATED PER CUBIC METER OF GAS. BASED ON 1000 CALORIES PER CUBIC METER OF GAS, WATER CONDENSED, AND TEMPERATURE OF EVAPORATION OF 90° C.

of combustion. The units chosen are 1 cu. meter for the gaseous and 1 kilogram for the solid fuels.

Since for comparisons of this sort it is necessary to set some numerical value for the quantities D, C and t_2 I have chosen the simplest possible values, that of zero in each case. s_1, the specific heat of the gases of combustion, is, of course, a variable depending not only on the composition of the gases, but also on the temperature. However, the variation is so slight over the range of temperature ordinarily used in drying and over the possible range of composition that I have considered it permissible to give it the constant value of 0.32 (for 1 cu. m.) in all cases. Fig. 1 shows the variation in specific heat of the gases of combustion of the four fuels considered with varying temperature and percentage of excess air, and will confirm the statement just made concerning its unimportance. Except in the case where it is desired to show the effect of excess water upon efficiency we may also put $H' = H_1$, since it is self evident that this is necessary for maximum efficiency for any per cent excess air. In cases III and III A to make the results comparable to cases I and II we can take n and m each equal to 1, so that $m_1 + 2\,m_2 = 2 - m_1$.

Introducing these values in our general equations we get the following simplified equations:

(1) reduces to

$$W_1 = \left(\frac{H + 606.5\,M - (V - V_1)\,0.32\,t}{606.5 + 0.305\,t}\right) - M_1. \quad (13)$$

(3) reduces to

$$V = \frac{H + 606.5\,M}{\dfrac{(606.5 + 0.305\,t)\,pp\,0.81}{1 - pp} + 0.32\,t} - V_1 \quad (14)$$

(4) remains unchanged.

The equations of Case II, i.e., (5) and (6), become the same as those simplified for Case I, i.e., as (13) and (14), respectively. This since Case II differs from Case I only in that the solid and excess water may pass out at a different temperature from that of the gases in Case II. If the amount of solid and excess water is made zero the difference between the two cases disappears.

In case III (9) reduces to

$$W_1 = \frac{H + 16\,V\,(2 - m_1)}{637} \quad (15)$$

In case III A (12) becomes

$$W_1 = \frac{H}{2\left(606.5 + 0.305\,\frac{t_1}{2}\right)}$$

The following table gives the values of some of the quantities involved in these expressions for each of the fuels considered.

	1 Cu.M. Hydrogen	1 Cu.M. Methane	1 Kilo. Carbon	1 Kilo. Coal
H (water uncondensed) Kg. Cals.	2613	8598	8100	7245
M (equals M_1) Kilos	.81	1.62	0	.54
V (fuel burned with theoretical air) Cu. Meters	2.905	10.62	8.91	7.89
V_1 Cu. Meters	1.	2.	0	.667
s_1	.32	.32	.32	.32

Taking up first Cases I and II there are four variables to be considered, to wit: W_1, W', V and t. First considering $W' = W_1$ (i.e., W_1 a maximum for each per cent excess air) the relation between V and t is given by (14) and the results expressed graphically are shown in Fig. 2. Note that with rising temperature the volume of gases decreases to the minimum, which results when the fuel is burned with the theoretical air. The volume, of course, remains constant at this minimum value for any further increase in temperature of evaporation.

Fig. 3 shows the relation between temperature of evaporation (i.e., temperature of escaping gases) and water evaporated. Note the double maximum. At zero we have an apparent maximum, which results theoretically because at that temperature no heat is carried out by the escaping gases *except as latent heat* in the aqueous vapor, hence all the heat furnished is used in evaporating water. As the temperature rises above zero the evaporation falls off rapidly to a minimum, which occurs at about 16° C. Above this it rises rather rapidly, to a second maximum at about 90° C. This is the practical maximum which should be aimed at in the operation of dryers, and is obtained when the fuel is burned with the theoretical air and W is so proportioned as to keep the gases just saturated without having any excess water pass out of the dryer unvaporized. Beyond this point as t increases the evaporation slowly decreases, the gases being no longer saturated, and,

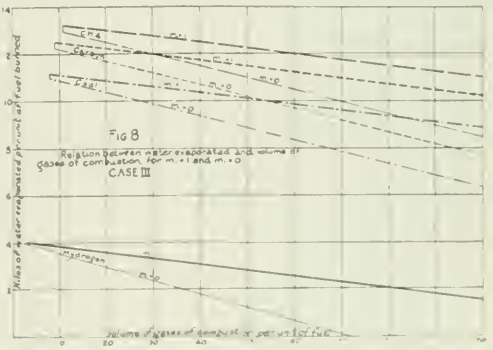


FIG. 8.—RELATION BETWEEN WATER EVAPORATED AND VOLUME OF GASES OF COMBUSTION, FOR $M_1 = 1$ AND $M_1 = 0$.

therefore, carrying out more sensible heat than they should. The data for Fig. 3 are calculated by means of equations (4) and (13) (4) applying from 0° to the second maximum and (13) beyond this point.

Fig. 4, which shows the relation between volume of gases of combustion and water evaporated, corresponds exactly to Fig. 3 and may be constructed from Figs. 2 and 3. The parts AB of the curves in Fig. 4 correspond to those parts to the right of

A on the curves of Fig. 3. The minima are the points C on each figure, while the maxima occurring at 0° on Fig. 3 are off the diagram on the right of Fig. 4.

Fig 5 brings in the other variable, W, which we have heretofore taken as equal to W_1. If the water added is greater than can be evaporated, it carries out sensible heat and decreases still further the evaporative power. If, on the other hand, it is less than could be evaporated, W_1 is again less than the maximum possible, since W_1 cannot be greater than W.

Fig. 6 is a comparison of the four fuels on the basis of an equal number of heat units. It gives the relation between temperature of evaporation and kilos of water evaporated per 1000 calories of heat developed. The data may be obtained from equations (13), (14) and (4) modified by substituting for $H + 606.5\,M$, 1000 calories; and for V, $\frac{1000\,V}{H + 606.5\,M}$

It will be noted that the form of the curves is exactly similar to those of Fig. 3, but the four fuels are now arranged with respect to their hydrogen content, that giving rise to the least water in the gases of combustion per 1000 calories developed having the greatest efficiency.

In Fig. 7 I have shown the relation between the per cent of water vapor in the gases of combustion and the evaporative power under given assumed conditions as to heat contained in a unit volume of gas and temperature of evaporation. It will be noted that for low percentages of water vapor the amount of evaporation is determined by the quantity of heat available in the gases, i.e., by equation (13), while for larger percentages of water vapor the evaporation is determined by equation (4), the quantity of water vapor which can be held by the gases. The position of the line AB, and hence of the point C, will, of course, vary with the quantity of heat per cubic meter of gas, while the position of the line XY, and hence again the point C, will vary with the temperature of evaporation.

Coming now to Case III the variables are W_1, V and m_1. Fig. 8 shows the relation between volume of gases of combustion and water evaporated for the two cases $m_1 = 1$—that is, very slow heating—and $m_1 = 0$—that is, very rapid heating. The maximum efficiency is seen to be obtained when the fuel is burned with the theoretical air and with slow heating. It is interesting to note that theoretically the efficiency of evaporation is not affected by the amount of water in the gases of

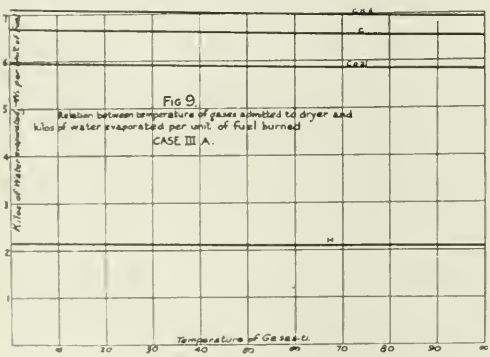


Fig 9.
Relation between temperature of gases admitted to dryer and kilos of water evaporated per unit of fuel burned
CASE III A.
Kilos of Water evaporated per Kilo of Fuel
Temperature of Gases t.

FIG. 9.—RELATION BETWEEN TEMPERATURE OF GASES ADMITTED TO DRYER AND KILOS OF WATER EVAPORATED PER UNIT OF FUEL BURNED.

combustion except in so far as affected by the term H, which, it will be remembered, is heat of combustion water uncondensed.

In Case III A, there are only two variables, W_1 and t. The relation between these two is shown in Fig. 9, and it is seen that there is only a very slight drop in evaporative efficiency with increased temperature of evaporation.

Finally, in Fig. 10, I have shown the comparative efficiencies of the several classes of dryers. From this it will be seen that there is but little to choose between the continuous and intermittent types as far as efficiency is concerned, but that the low temperature intermittent dryer has an efficiency only about half that possible with the other forms.

In conclusion, let us summarize the practical lessons which we may learn from this theoretical study, bearing in mind, however, that some of our assumptions will not hold strictly true in practice.

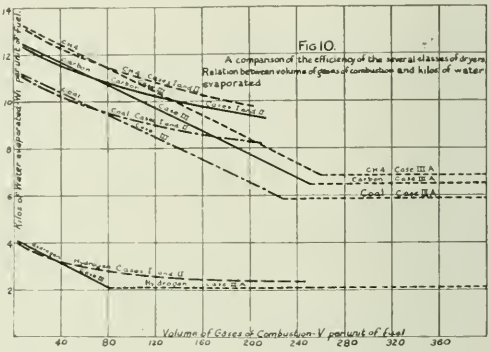


Fig 10.
A comparison of the efficiency of the several classes of dryers.
Relation between volume of gases of combustion and kilos of water evaporated
Kilos of Water evaporated per Kilo of Fuel
Volume of Gases of Combustion V per unit of Fuel
Coal Case III A
Coke Case III A
Coal Case III
Coke Case III
Wood Cases I and II
Wood Case III

FIG. 10.—A COMPARISON OF THE EFFICIENCY OF THE SEVERAL CLASSES OF DRYERS. RELATION BETWEEN VOLUME OF GASES OF COMBUSTION AND KILOS OF WATER EVAPORATED.

First, the conditions of maximum efficiency for the parallel current dryer are found when the fuel is burned with the theoretical amount of air, the temperature of the escaping gases is about 90° C., and no excess water escapes from the discharge end of the dryer. A temperature of escaping gases of from 80° C. to 120° C. will give a satisfactory economy.

Second, in the case of the counter-current dryer the conditions are somewhat different, since here the solid dried materials must pass out at a temperature approximating or equal to the temperature of the gases of combustion as they enter the dryer. The temperature of these gases will be at the maximum when the fuel is burned with the theoretical air, hence the maximum heat will be carried out by the dry solids under this condition

The conditions for getting maximum efficiency will, therefore, depend on the amount of solid and its specific heat, as well as on the other variables previously discussed, and only in case pure water is being evaporated can the counter-current dryer have a possible efficiency equal to that of the parallel current form.

Third, in the intermittent dryer I have assumed perfect heat exchange between the hot gases and moist material in the dryer. It is more difficult to realize this condition in this than in the other forms of dryers; in fact, impossible in most cases. Hence, the practical efficiency of the intermittent dryer will invariably be less than that shown and less than the parallel dryer when properly operated.

The conditions for maximum efficiency are slow heating up, and fuel burned with as nearly as possible the theoretical amount of air.

Fourth, low-temperature direct-heat dryers must necessarily have a very low efficiency, only about half that possible with other forms.

Fifth, the presence of hydrogen in fuels decreases materially their value for drying purposes. For use in dryers fuels cannot be properly valued on the basis of heat units alone, but should be compared as to drying efficiency by means of the equations here given.

University of Cincinnati.

Cementation.

BY ALFRED SANG.

Cementation.—"The fact that alloys can be formed by the union of two metals at a temperature below the melting point of the more fusible of the two, has long been known to metallurgists."[1] Records of that knowledge go back to the year 1820.[2]

The two most widely used processes of cementation are those of malleableizing iron and manufacturing blister steel, so-called on account of the blistered appearance of the surface; the even distribution of these small blisters is an indication of uniform carburization. These blister-bars, which are used in making the finest grades of crucible steel, such as cannot be produced from the best open-hearth billets of the same composition, absorb carbon to a considerable depth by being buried in charcoal and heated for seven to eleven days, depending on the degree of carburization desired—at a temperature of about 1000° C.; it takes two to three days to bring the furnace up to heat and about fourteen to cool it slowly down. The dilation of the metal by heat produces porosity and favors diffusion. The subsequent melting in crucibles distributes the carbon throughout the metal and ensures homogeneity. In the case of "shear steel" the bars are simply piled and welded together.[3]

According to Prof. Arnold, it is impossible to introduce much over 2 per cent of carbon into iron by cementation, even after repeated treatments. Case-hardening is a form of cementation to give a hard skin to objects which are to undergo severe wear, but no blisters are formed. Blisters do not appear either when remelted iron or mild steel are treated, because the slag has been eliminated by previous treatment; it is the action of the carbon on the slag which raises the blisters, carbonic oxide being formed in the body of the metal softened by heat.[4]

Theories of Cementation.—Sydney Marsden has classified the theories of cementation as follows:[5]

1. By the occlusion of gases, a theory first proposed by Lepkay,[6] carbonic oxide (CO) is supposed to lose some of its carbon to the iron, thereby being converted into carbonic dioxide (CO_2), after which, through contact with the carbon, it is reduced back to carbonic oxide.

2. By the direct combination of the carbon with the iron by contact to form a carbide; this theory makes it very difficult to understand how the operation progresses toward the center of the metal treated.

3. By the inter-solution of the carbon and iron. It is difficult to believe that the low temperature of the process will induce sufficient molecular activity to bring about such a result within a reasonable period of time. Roberts-Austen has favored this view.

4. By the diffusion of the carbon through the iron, which is rendered porous by heating; this is Marsden's own theory and was founded on his experiments on the diffusion of carbon through red-hot porcelain. This theory would seem to require that the carbon be present in the pores of the iron in a very finely divided state, but this hardly justifies the claim that on this account no carbide can be formed. Diffusion may be the means of securing intimate contact and other proper conditions for a chemical reaction of which a hardening carbide would be the result.

Auguste Laurent[7] had claimed that the carbon must be present as a gas to produce cementation, but the temperature of the process being far below the point of volatilization of carbon, he concluded that it must be present as carbonic oxide. This was later authoritatively confirmed by H. Behrens.[8] It is important to note, however, that M. F. Margueritte discovered[9] that diamond in contact with iron would also bring about cementation, but *only at the points of contact*, thus proving the diffusion of carbon through iron in immediate contact with it, at a temperature very far below its point of volatilization. It is evident that the laws of contact action must be scrutinized for an explanation. Capt H. Caron[10] claimed that in all cases a cyanide must be formed to cause cementation; to supply the cyanogen (CN) both carbon and nitrogen would in this case be indispensable to the process.

While the theory of diffusion is the most acceptable one, the question as to whether it is a carbide or the carbon itself which is diffused, still remains open. A commercially useful rate of diffusion takes place as low as 800° C., but the action is most rapid between 1000° and 1100° C. If the diffusion depends, as is most likely, on the condition of the iron as well as on that of the carbon, this temperature should be the best, from the point of view of the iron, for cementation by any element.

Electro-Cementation.—J. Garnier inquired into the effect of an electric current on the process of cementation; his first experiment" consisted in placing pieces of iron and retort carbon in contact, the iron being the negative pole; after applying a current of 7 volts and 55 amp. for several hours, signs of cementation were found. His next experiment[11] was to place two iron bars (analyzing 0.001 C.) 0.4 inch apart, with charcoal dust between them, then heating to the usual temperature of cementation and applying a current of 2.5 volts and 55 amp. for three hours, he found that the piece of iron forming the negative pole was cemented to a considerable depth, but the one forming the positive pole had remained unchanged.

This result would seem to indicate very clearly that cementation is at least partly due to contact electricity; the cementing material or "cement" must, at the temperature of working, be positive to the metal treated. In the same way a high-carbon steel will carburize iron heated in contact with it. The action is reversed in the case of malleableizing; the carbon is withdrawn from the iron by heating it in contact with fine hematite ore. The carbon or cement-metal will travel in the negative direction of the contact current set up. The current causes apparently a true convection of molecules which have been dissociated by an effect of the porosity of the hot iron similar to that of zinc dust, spongy platinum and other catalytic decomposing agents. Solution of these molecules does not have to take place if their dissociation can be brought about without it.

Dry Galvanizing or Cementizing.—The inventor of the first practical process of galvanizing by cementation, now commonly known as dry galvanizing or cementizing, was Miles Berry, an Englishman, from whose British patent, dated 1838 (No. 7630), I quote as follows

"The alloying or changing of metals by cementation is a process well known in metallurgy, but I am not aware that any metal has ever been before so changed or protected by this process that it would resist the action of air, or humidity, or of certain acids, whereas copper and iron, both wrought and cast, and other oxidizable metals, when they have been subjected to the said process, according as the same is modified to suit each particular description of metal, resist all these sources of oxidation

"And first, as regards copper, after it has been cleansed it is placed in a furnace covered with a mixture of charcoal and powder of zinc, and the temperature then raised to cherry red,[12] which degree of temperature is kept up for a longer or shorter period, according to the bulk of the article or to the desired thickness of the coating and color to be given to the article The operation is one of great nicety, for which I am

[1] Roberts-Austen: An Introd. to the Study of Metall. Ed. 1902, p. 72
[2] Faraday and Stodart: Quarterly Jl. of Sci., vol. IX (1820), p. 319
[3] See Harbord & Hall: Metall of Steel, Ed. 1905, p. 220 & foll
[4] Dr. Percy: Jl. Iron & St. Inst., vol. I (1878), p. 116.
[5] Jl. Chem. Soc., April, 1881.
[6] An. de Ch. et de Ph., Yr. 1846.
[7] An. de Ch. et de Ph., Vol. 65 (1837), p. 427
[8] Oesterr. Zeits, fur Berg- u. Huttenwesen, vol. XLIII, p. 198.
[9] An. de Ch. et de Ph Yr. 1865, p. 75
[10] An. de Ch et de Ph October, 1865.
[11] Hallauret: bef Soc. Int'rn. de Elec; Ind. & Iron, vol. XV, p. 182.
[12] C. R., vol. CXVI, p. 1449.
[13] 700° C. (1292°F) corresponds to "full cherry-red" (Howe).

informed no definite rules can be laid down, but that experience will enable any competent workman to perform it with sufficient exactness. It will be found that in every case there is a point at which the copper, when taken out of the furnace is perfectly inoxidizable, whereas, if the operation last too long, the produce is nothing but common brass very readily oxidized."

He then goes on to describe a method of dipping iron in a fused alloy of 3 parts copper and 2 parts zinc, after which the articles are heated to redness in charcoal dust until zinc fumes cease to be given off; they are then plunged in water and allowed to cool slowly. A third process which he claims, is to pulverize the above alloy when cold and dip the iron articles previously smeared with oil or grease into this powder, and then to heat them in charcoal dust. I quote further from his patent as follows:

"A fourth variety of the process is to dip the iron into a solution of sulphate of copper (after being perfectly cleaned) and to suffer it to remain there for a time. As soon as the iron is covered with a sufficient covering of precipitated copper, it is taken out, plastered with potter's earth mixed with water, and then covered with a layer of pulverized zinc and borate of soda, or other substitute for the same, or the pulverized zinc, borate of soda, or other substitute may be made into a paste with the clay and water, and the article smeared over with the said paste. The iron is then placed in the furnace covered with charcoal powder and heated to white heat for some minutes. The rest of the process is the same as before described. The metals thus rendered inoxidizable are either of a gold or silver hue, according to the length of the operation or the quantity of zinc that combines with the copper. The brightness of the gold color alloy may be enhanced by rubbing the article with vegetable charcoal, or the soot from a wood fire, and nitric acid. It is proper to add, that instead of pulverized zinc, I have been informed pulverized calamine[14] may be used."

The broad claim is then made of a process for "alloying by cementation . . by which copper, iron and other oxidizable metals are preserved from oxidation, their surfaces are changed in appearance and also rendered more brilliant."

Berry's observation, that a zinc salt-like silicate of zinc could be used instead of the metallic powder, was borne out in Dumas' discovery of a process for galvanizing by heating the object to redness in a closed retort with zinc oxide and powdered charcoal.[15] To iron and cast-iron articles he gave a slight coating of copper by immersion in a solution of sulphate of copper; the film of copper was necessarily converted into brass. If a piece of copper wire is placed in zinc oxide and heated in a closed retort, it is in a very short time converted into a very brittle brass.

It is, therefore, evident that the modern process of sherardizing is a sort of combination of the ideas of Berry & Dumas, the articles being buried in zinc dust (oxidized zinc powder) or in zinc powder, to which zinc oxide is added, and then heated to a dull red heat.[16]

Early Attempts.—The following extracts from British Patent No. 1963, of 1864, granted to Neil McHaffie, for a method of treating iron plates for shipbuilding and boiler-making and wrought iron in other forms, are interesting.

"For these purposes the wrought iron, whether it be in the form of plates or sheets, or forged or fashioned to any desired shape, is surrounded with oxide of iron, or oxide of iron ore, or with oxide of manganese, or oxide of zinc, or matters containing these or similar metallic oxides or substances, and the whole is heated by preference to a full red heat;[17] it is maintained at this temperature for many hours, and afterward is gradually cooled. The wrought-iron plates, sheets, forgings or other pieces will by this treatment be found to have undergone a peculiar change, which enables them to resist more or less completely destructive or corrosive influences."

He recommends air-tight "troughs of iron," and states that the treatment should be continued from 12 hours to three days, depending on the nature of the articles. He prefers using oxide of iron, and states that the work, on being immersed for a length of time in sea water, is found to be free from shell fish or marine animals, and also, in a degree, from corrosion or rust.

Mr. Isaac E. Craig, of Camden, Ohio, has taken out several patents for improvements in methods of cementing iron sheets by means of carbon and metallic oxides, to render them rust-resistant. In one[18] he packs oxide of antimony, tin or lead between the sheets and then heats them to redness, after which they are "burnished, rolled or hammered in the usual way." In another[19] he claims a deoxidizing of sheets, followed by their alloying by applying to the surface a composition of carbon and one or more of the same oxides, and heating to redness in a furnace. In a third patent[20] he claims the coating of the sheets with carbon, and any or a combination of the same oxides previous to the final heat and working.

In Craufurd's patent of 1837, for hot galvanizing, the process of using pulverized zinc as a paint was included. In a patent of de Fontainemoreau, of 1838, the following method for preparing the powder is given:

"The zinc is put into a reverberatory furnace, every opening for the admission of the atmospheric air carefully closed, and the temperature of the melted zinc raised to a degree approaching red heat. The door is then opened and the zinc skimmed, after which one-tenth of its weight of wrought (not cast) iron filings moistened with muriatic acid (to which some sal ammoniac may be added) is thrown into the fused metal, which must be stirred all the while; after the introduction of the filings the surface of the metal must be covered over with fine charcoal powder and the temperature carried to about the cherry-red heat, at which temperature the metal must be maintained for one hour, stirring it occasionally with an iron poker. The melted metal is then conveyed into a brick or cast-iron trough, covered over with a lid of cast iron to exclude all contact with the atmosphere; the metal is then stirred by means of an iron rod passing through a hole in the cast iron door until by cooling it becomes so solid that it can be stirred no longer; when quite cool it is ground into powder, and the more friable it is the better the operation has succeeded. The powder so obtained will preserve from oxidation copper and iron, polished and filed steel, such as clockwork, articles of hardware, ironmongery, etc., by merely covering the articles with the powder, and this, even though they should be exposed to wet or damp. The zinc may be also applied through the medium of a paint or paste, in manner which I shall next proceed to describe: The powder of zinc is mixed with any of the unctuous substances generally used in paints and varnishes. The substances which have been found to answer best are those which were conductors of galvanic fluid, and hence this has been commonly called galvanic paint. Very good paint is to be made with oil distilled from the refuse tar of the gas manufactories, adding one-third of spirit of turpentine; oil varnish may also be used, but it is very expensive; linseed oil may be employed as it is in common paint, but is not quite so favorable to the galvanic effect of zinc; lead or ceruse may be added to the paint to give it some consistence. The proportions of the materials of the paint depend on the substances with which the zinc powder is mixed, and on the uses to which the paint is to be applied. With the same powder a paste may be made; by rubbing copper, steel or polished iron with the same they will be effectually protected. This paste is

[14] Silicate of zinc (H_2 Zn_2 Si O_5).
[15] Bull. Soc. Ch. et Ph., vol. IV (1865), p. 374.
[16] 550° to 625° C. (1022° to 1157° F.) corresponds to "dull-red" (Howe).
[17] Full cherry-red, or 700° C. (1292° F.).
[18] U. S. Pat. No. 237,963, of 1881.
[19] U. S. Patent No. 241,529, of 1881.
[20] U. S. Patent No. 321,693, of 1885.

made with melted wax, into which is put ten times its weight of powder of zinc and about one-fiftieth of tallow or oil.

"For protecting small polished metal articles I employ a zinc paper or wrapper, manufactured by mixing powder of zinc ground very fine with the pulp of the paper while making, or by powdering common paper previously covered with some glutinous substance, such as gum or flour paste, taking care always to exclude the use of animal glue, which has a tendency to cause the iron to rust."

Various combinations of the rusts of zinc, lead, antimony and copper have been proposed as anti-fouling compounds, when mixed with a suitable fluid medium.[23]

Present-Day Methods.—Protective coatings obtained by cementation with metallic dusts, have been carried out for many years in a commercial way. Sheet-steel cow-bells have been given their brass coating and their tone by packing them in finely divided brass and charcoal dust, contained in a plumbago retort, which is made air-tight by luting with clay. The retort is then heated in a furnace. It has been found in the case of gold that simply rubbing the articles with gold dust would leave a deposit.[24]

The author has found that a brass dust[25] of a beautiful green color could be prepared for coating iron articles at low temperatures by mixing zinc dust and copper dust and heating the mixture at a low heat in an air-tight retort; the copper dust was obtained as a fine purplish-brown precipitate, by adding zinc dust to a solution of copper sulphate, the exchange of the metals taking place instantly with evolution of heat; special care is required in the drying to prevent the formation of too much oxide. It was found that the brass dust could be used repeatedly without deterioration and without the necessity of adding a hydrocarbon to the charge; the coating obtained by this method is smooth and homogeneous and of a golden color; it adheres so well that the pieces can be bent and hammered without the slightest evidence of scaling. If instead of brass dust a mixture of zinc and copper dusts is used, the articles have a first coating of pure copper blending into an outer coating of zinc; the mixed dusts are more or less converted into brass dust, and if the heat is too great beads of brass are formed.

Copper dust obtained by the method just described can be used for coating metals by cementation. When copper is precipitated by adding zinc to a copper sulphate solution, there is a slight but continuous evolution of hydrogen, as already observed by Leykauf in 1840, and a basic zinc sulphate is formed. According to Lothar Meyer[26] there is no cuprous oxide formed. J. B. Senderens found[27] that in 10 per cent only of all cases of metallic precipitation which he investigated was the precipitation even approximately that of equivalent for equivalent. A careful study of the properties of copper sulphate solutions and the precipitation of metals has been made by R. M. Caven.[28] His results accord with those of Lothar Meyer, excepting that he detected the presence of cuprous oxide.

The process of Sherardizing has been described elsewhere.[29]

Diffusion Under Pressure.—Prof. Walthère Spring, of Liège, has studied the effects of high pressure on pulverized solids,[30] and discovered that alloys could be produced by compressing the intimate mixture of the dusts of the component metals; his work in that direction, which was very thoroughgoing, was confirmed by Sir W. Roberts-Austen[31] and supplemented by the researches of Fawsitt[32] and Lehmann,[33] and the general results have been embodied in a masterly report by Prof. Spring before the International Congress of Physics of 1900.[34]

The following are the observations of Prof. Spring in the case of finely divided zinc:[35]

"Zinc filings will be completely welded under 5000 atmospheres (75,000 lb. per square inch); the mass scarcely commences to flow under 7000 atm. (105,000 lb. per square inch).

"The binding of the zinc filings deserves close observation, because, taking place as it does with great difficulty, it is readily understood that after all it only depends on the intimate contact of the particles. All phenomena observed with zinc apply to other bodies without exception.

"Under a pressure of 700 atm. (10,500 lb. per square inch), a slight degree of binding is observed; the block can be taken from the press, but it is easily broken and will then disintegrate. Examined under the microscope under 500 diam. of magnification one can readily detect *voids between the grains*, they only touch at a few points. Under 2000 atm. (30,000 lb. per square inch) the cohesion is such that the block can be filed, but when hammered it will break. The break, when examined under the microscope, still shows some voids between the grains, but they are far less numerous; on the other hand, in many places thorough agglomeration is evident. Under 4000 atm. (60,000 lb. per square inch) the number of voids has dwindled further. Only very few are to be found, and they are difficult to trace; under 5000 atm. (75,000 lb. per square inch), the block is a perfectly continuous mass which can be put in a vise and be filed and hammered like a block produced by fusion.

"I then compressed zinc powder at a temperature of 130° C. (266° F.), the temperature at which the metal is most malleable. The powder was even more closely welded and the block showed a crystalline break."

The molecular diffusion giving rise either to agglomeration of similar or alloying of dissimilar powders, is considerably aided by friction of the particles among themselves or against the walls of the dies. The oxides of the metals cannot be pressed into a continuous mass,[36] and in that respect zinc dust acts as an oxide and cannot be pressed into a solid mass of zinc at ordinary temperature; it is compressed into a crystalline mass at a temperature of 130° C., but this is due to peculiar conditions which are peculiar to zinc dust (see footnote 27).

Diffusion Without Pressure.—Diffusion will take place and alloys will be formed without compression of the dusts if they are brought into intimate contact,[37] but the operation is slow. This applies to sheet metals also. The action can be hastened by even a moderate application of heat, far below the temperature of fusion of the metals in contact; after from 3 to 12 hours of contact, Spring obtained a perfect weld; in the case of zinc and copper the metals were alloyed to a depth of .25 mm. The bearing of the principles underlying the diffusion of solid metals on galvanizing by cementation is evident.

A law due to Hallock,[38] which seems to be correct as far as it goes, but does not explain a multitude of phenomena, because it disregards several important limiting factors, such as exposed surface and physical variations of the metals, is as follows: "An alloy can be produced out of its original constituents without considerable pressure if the temperature be above the melting point of the alloy, even if it be far below the melting point of the most easily fusible constituent."

[23] e. g. Engl. Pats. No. 16,107 of 1893, and No. 9,417, of 1891.
[24] Zeits. für Instrumentenbau, vol. 3, p. 258.
[25] Patented.
[26] Deuts. Chem. Gesell. Berlin, vol. 9, p. 512.
[27] Bull. Soc. Chim. 3e Ser., vol. 17, p. 271.
[28] *Jl. Soc. Chem. Ind.*, vol. 19 (1900), p. 18.
[29] See El. Chem. & Metall. Ind. vol. 5 (1907), p. 187; vol. 6 (1908), p. 189.
[30] *Jl. Phys. Soc.* Yr. 1882, p. 231.
[31] *Deuts. Chem. Gesell.*, vol. XV (1882), p. 1907.
[32] *Dingl. Pol. Jl.*, vol. CCXXXII, p. 482.
[33] *Wied. Ann.*, vol. XXIV (1885), p. 5.
[34] Rap. Cong. Int. Phys., vol. I., p. 412.
[35] Abstract in An. de Ch. et de Ph., Yr. 1881, p. 182.
[36] L. Henry: *Phil. Mag.*, 5th Ser., vol. XX (1885), p. 81.
[37] W. Spring: Bull. Acad. Roy. Belge, 3e Ser., vol. XXVIII (1894), p. 23.
[38] U. S. Geol. Survey, Bull., 60 (1890).

Iron and Steel Institute.

The autumn meeting of the Iron and Steel Institute was held in London from Sept. 28 to Oct. 1. In the following we give abstracts of the papers presented

A report of the discussions which followed the presentation of the papers and a general report of the proceedings will be found elsewhere in this issue in the letter from our London correspondent. (See page 491.)

Dry Blast.

Two papers dealing with dry blast were presented by Mr. Greville Jones and Mr. R. S. Moore.

Mr. Jones' paper on "uniform moisture in blast" is a report on an experiment carried out at the Clarence Iron Works in 1909, on the question whether the principal saving in fuel in the Gayley dry-blast process is due to uniformity of blast or to its dryness. The results are in favor of the latter assumption.

Mr. R. S. Moore discusses "the fuel economy of dry blast as indicated by calculations from empirical data." In referring to the above-mentioned experiments, he points out that the results of the test strongly point to the fact that the great heat saving of the Gayley dry blast must be due to its dryness. The theoretical explanations on this basis have not been supported by any actual experimental proof, and they have apparently been as much rejected as accepted.

The principal experimental proof which is lacking is data on the saving of fuel to be secured by adding heat to the bosh. In studying the conclusions suggested by the test it occurred to the author that this hiatus is supplied by the results of experience with the Neilson hot blast.

Fig. 1 is a curve representing the relation between temperature of hot blast and coke saved on cold-blast requirements, the data for the points from which this curve is plotted being taken from Sir Lowthian Bell's book on "The Principles of the Manufacture of Iron and Steel."

A curve which represents the variations of coke consumption with heat added to the blast, also represents the combined effect of all physical and chemical changes taking place in the blast furnace, whether the heat changes have to do with carbon

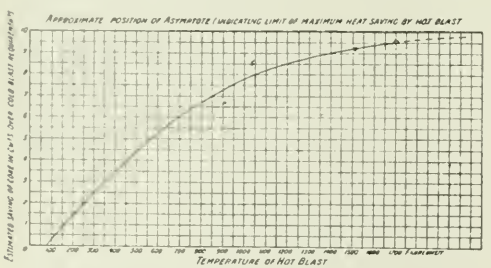


Fig. 1.—Temperature of Hot Blast and Coke Saving.

monoxide reduction, the carbon reduction, or the heat absorbed by the iron, the slag, or by heating stock. It is, therefore, a curve of practice rather than of theory, in so far as it is accurately plotted.

It is evident from the slope of the initial portion of the curve that a saving of 1 cwt. of coke is obtained for approximately each 100° Fahr. increase of blast temperature. The heat added in the blast per 100° per ton of iron is 276,000 b.t.u. One hundred and fifty-four thousand b.t.u. are required per ton of iron to disintegrate 1 grain of moisture per cubic foot in the blast. This heat is, therefore, equivalent to $154{,}000 \div 276{,}000 = 0.56$ cwt. on the initial portion of the curve.

But the saving in the upper portion of the curve is less than ½ cwt. per 100° Fahr., and the question now arises: What portion of the curve applies to the heat necessary to disintegrate moisture? It is a well-known fact that for the economical reduction of iron oxide in the blast furnace, as large a proportion as possible must be reduced by carbon monoxide.

Now, as this reduction occurs most readily at about 1100°, and decreases rapidly at higher temperatures, and as the temperature of the stock entering the furnace soon approaches this point, it follows that a limit to the amount of heat which should escape in the gases rising from the bosh is soon reached. It was pointed out by Sir Lowthian Bell years ago that the economy of the Neilson hot blast was due to the fact that adding heat to the blast enabled it to supply much of the heat necessary in the bosh to melt the iron and slag. The heat which was thus absorbed did not have to pass through the upper carbon-monoxide reducing zone, thereby heating it and retarding the reduction.

Now, the heat which the iron and slag require is only about 18 per cent of the total; it appears self-evident, therefore, that the fewer heat units which are added to the blast, the easier it is for the iron and slag to absorb them before they pass out of the bosh; but as the 18 per cent is approached more and more escape to the reduction zone. Therefore, removing the moisture before it enters the furnace is equivalent to utilizing all the heat necessary to disintegrate it in melting the iron and fusing the slag. The economy to be expected from low moisture alone is, therefore, that represented by the initial portions of the curve, or 1 cwt. of coke for 100° Fahr. temperature of blast, or, as pointed out before, 0.56 cwt. per grain of moisture per cubic foot.

If 5 grains be taken as the average amount of moisture which can be eliminated, this would be equivalent to $5 \times 0.56 = 2.8$ cwt.; $2.8 \div 20 = 14$ per cent of 20 cwt. per ton of iron.

About 2 grains of moisture were added to secure uniformity and no gain or loss was found except a very slight lowering of the silica, indicating that the harmful effect of the 2 grains added was almost neutralized.

If it be assumed that the heat gain due to uniformity is equivalent to one-half of this, or to the effect of 1 grain, the foregoing considerations would account for a saving of about 17 per cent of fuel for dry blast. It may be said that a saving of 2.8 cwt. on 28 cwt. coke consumption on cold-blast is not necessarily equivalent to a saving of 2.8 cwt. on 20 cwt. hot-blast consumption.

There must, of course, be some difference, but it is probably very slight, because, while under cold-blast consumption 40 per cent more coke is burned than under hot-blast, 50 per cent more ore is contained in the furnace under hot-blast conditions. Therefore, while there is less carbon monoxide generated, it acts on 50 per cent more ore, and under better conditions of efficiency, namely, lower temperature. The rate of increase of ore volume to coke volume is also approximately twice as great per hundredweight of coke decrease at 20-cwt. hot-blast consumption as at 28-cwt. cold-blast consumption. The coke saving in the two cases should, therefore, be very closely similar.

Iron Paint.

A paper by Mr. F. J. R. Carulla on "artificial magnetic oxide of iron" refers back to the same author's former paper on a new iron paint invented by Dr. Wülffing (our Vol. V, page 395).

The chief points brought out in the present paper are:

Firstly, that to William Gregory, of Edinburgh, must be assigned the discovery of the artificial production of magnetic oxide of iron.

Secondly, that there are grounds for believing that magnetic oxide of iron made by the above process is either Fe_3O_4 or Fe_4O_5, and that any variation from these formulas is due to admixture of Fe_2O_3.

Thirdly, that to say whether the main portion of any sample is Fe_3O_4 or Fe_4O_5 is not a matter that can be asserted with certainty, although there are indications that two distinct bodies exist in different samples, one of these being most difficult of solution.

Fourthly, that notwithstanding those difficulties that all beginners are sure to encounter, the product is difficult to spoil in the making except as regards color, and the operator can

soon attain to the production of a commercially uniform article.

Finally, it may be added, that the protective character of this magnetic oxide of iron is most marked. Just as the Bower Barff coating and the film on Russian sheet iron, both magnetic, afford protection to iron surfaces, so does this product when laid on in the form of paint.

The action that takes place through the localization of scale on iron plates must not be thought to militate against the use of a magnetic iron paint. It might as well be argued that because a hot ember will burn a hole in the flesh, therefore, diffused warmth must also be harmful.

The great protective value of what one may be allowed to call the Gregory-Wulffing magnetic oxide of iron paint is acknowledged by all who have had any experience of it.

Corrosion of Iron.

Two papers on this subject were presented by Dr. J. Newton Friend.

The first paper, entitled "The Corrosion of Iron," is essentially a reply to some recent criticisms by Dr. W. H. Walker. Dr. Friend emphasizes that he is not an adherent of the "carbonic acid theory of corrosion," but rather of the general "acid theory of corrosion." He claims that "pure water, oxygen and iron may remain with one another for an indefinite period without the formation of rust. The presence of a trace of some acid to act as catalyser is absolutely essential if oxidation of the metal is to begin." He agrees that the acid theory is in harmony with the electrolytic theory of ionization.

Dr. Friend's second paper deals with "the action of air and steam on pure iron." The results of his experiments are summed up as follows:

1. Pure iron combines with ordinary air and with air dried over phosphorus pentoxide with increasing readiness as the temperature rises. Below 150° C. the oxidation proceeds too slowly to be readily detected.

2. When pure iron is heated in pure steam at temperatures ranging from 350° C. upward, the metal becomes tarnished.

3. The author concludes that the action of steam on iron takes place in two stages, comprising, first, the dissociation of the steam, and, second, the combination of the dissociated oxygen with the iron, and the consequent liberation of free hydrogen gas.

4. If conclusion 3 is correct, the dissociation pressure of the oxide of iron produced at 350° C. is of the order of 1.02×10^{-12} atmosphere.

Production of Iron and Steel in the Electric Furnace.

A paper by Mr. E. J. Ljungberg gives in the introduction some notes on steel making in the electric furnace in Sweden.

At Gysinge, one of the works belonging to the Stora Kopparbergs Bergslag, there is one Kjellin induction furnace with a capacity of 2 tons, but as this is working as a Talbot furnace, not more than about 1 ton at a time is tapped.

The power continuously used in this furnace represents about 200 kw., and the output in 300 days amounts to about 1200 tons of ingots, using 50 per cent. pig and 50 per cent. scrap. As no other pig iron is used except the famous Dannemora brand made by the firm, which, as everyone knows, is extremely low in phosphorus and sulphur, the process can hardly be called a refining process.

The product is a carbon steel of high quality, possessing some superiority over steel made by the ordinary melting processes, one special quality is that it is comparatively soft to work, either hot or cold, although high in carbon. It is a superior carbon tool steel.

It may be of interest to state that the company makes about 15,000 tons of Dannemora charcoal pig iron annually, of which about one-third is exported and two-thirds are used at the works at Soderfors and Elfkarleo for the manufacture of Dannemora Wallon bar iron, open-hearth and crucible steel.

The main part of Mr. Ljungberg's paper deals with the interesting and extended experiments made at Domnarfvet with iron-ore reduction in the electric furnace. These were fully described in Dr. E. Haanel's paper and official report, published in our June issue, page 250, and October issue, page 420.

Carbon Tungsten Steels.

Mr. Thomas Swinden's paper on the constitution of carbon-tungsten steels results in the following conclusions:

Hardness tests and exhaustive microscopic examination support in every respect the conclusions previously recorded upon the cooling curve work. Firstly, that the "lowering temperature" marks a definite reaction in which the tungsten is involved; and, secondly, that the rate of cooling from above the lowering temperature is without the influence on the low point. Some facts are stated and observations made, suggesting that the hypothesis of Edwards, that the lowering of the point is due to the formation of the carbide of tungsten, is untenable.

The theory of a double carbide formation is also difficult to account with cooling curves and microscopic facts. A tentative hypothesis is given, wherein the lowering of the recalescence point is attributed to the solution of a tungsten compound, probably Fe_3W, at the lowering temperature. The tungstide is reprecipitated at the low point, and the Fe$_3$C immediately separates also.

Some figures in support of the latter view are included.

Economy of Rolling Mills.

Mr. C. A. Ablett in his paper on "the determination of the economy of electrically driven reversing rolling mills" pointed out the advances made in recent years in this direction, which appears to be amply justified by the economy obtained in spite of the increased capital expenditure. At the present time, the question of saving in fuel consumption appeals to most steel makers as the chief inducement offered by electrical driving as the possibilities in the direction of greater output are not fully recognized, there being as yet no published figures relating to this. It is, therefore, of interest to consider the methods by which the economy in fuel, power or steam consumption can be ascertained.

Tests are frequently made to determine the economy of a reversing mill engine, either

(1) By indicating the engine and estimating the steam consumption per indicated horse-power from some of the larger diagrams; or,

(2) Where boilers can be isolated, by measuring either the feed water or the coal burned for a considerable period, and keeping a record of the tonnage of steel rolled over that period, so that the result is expressed in pounds of coal or pounds of steam per ton rolled.

The author discusses critically these two methods, and explains his reasons for thinking that they have comparatively little value. The energy consumption of an electrically driven reversing rolling mill, as expressed in kw-hours per ton rolled, can be determined in the simplest possible manner by inserting an ordinary watt hour meter in the supply system. If a reading of this instrument before the commencement of a shift and a second reading at the end of the shift are taken, the difference gives the total kw hours used during the shift, and dividing this by the tonnage rolled, the total kw hours per ton is obtained. Such readings can quite easily be taken for every shift, and a continuous check on the energy consumption can be kept.

Results expressed in kw-hours per ton are generally found most useful, as the cost of the kw-hour varies according to local conditions, and knowing this cost, the total cost of power can be arrived at directly. The efficiency of the electrical plant can also be checked in the simplest possible manner by placing a second integrating wattmeter in the armature circuit of the mill motor.

The records of this wattmeter will be less than those of the one placed in the supply circuit, the difference being the losses in the electrical plant. This does not take account of the

efficiency of the mill-motor armature, but as this is of the order of 97 per cent to 98 per cent, it can well be neglected. The following figures show some characteristic values for the kw-hours per ton rolled obtained from tests on reversing mills:

	kw-hours per ton.
4½" x 4½" billets from 2.5-ton ingots. Output 53 tons per hour	22.5
6" x 6" blooms from 2.5-ton ingots. Output, 63 tons per hour	17.5
8" x 8" blooms from 2.5-ton ingots. Output, 80 tons per hour	13.0
12" x 9½" blooms from 7-ton ingots, measuring 34½" x 25". Output, 65 tons per hour	11.2
32" x 9" slabs from 6-ton ingots, measuring 36" x 19½". Output, 40 tons per hour	4.3
32" x 5" slabs from 6-ton ingots, measuring 36" x 19½". Output, 40 tons per hour	5.8
Flange rails, 100 lb. per yd. from 2-ton ingots. Output, 30 tons per hour	48.0
Beams, 120 lb. per yard, from 1.5-ton ingots	36.0
Channels, 92 lb. per yard, from 1.5-ton ingots	37.0

Tests of Cast Iron.

The very great variations in the tests which have been obtained from cast iron from time to time, and the differences of opinion which exist as to the best methods of testing, determined Mr. E. Adamson to make the comparative tests which form the subject-matter of his paper on tests of cast iron. These tests were all carried out in actual foundry practice. The chief results are as follows:

The best tensile and transverse tests are obtained from bars which have been machined, instead of bars tested as cast with the skin on.

Transverse test-bars cast on edge and tested with the "fin" in compression give the best results in testing.

The transverse test is not so reliable or helpful as that of the moment of resistance.

The use of high-grade ferro-silicon in the foundry is of no commercial value.

Cast iron gives the best results when poured as hot as possible.

The "Growth" of Cast Iron.

A paper by Prof. H. F. Rugan and Prof. H. C. H. Carpenter deals with the peculiar phenomenon of "the growth of cast irons after repeated heatings," which had first been studied by Mr. A. E. Outerbridge, Jr.

The present authors have made an extended investigation in which they determined the conditions under which the maximum growth of commercial cast irons is brought about by repeated heatings.

For growth to take place both heating and cooling are required. A given specimen grows no more under a 17 hours' than a three hours' treatment.

Three commercial cast irons were investigated. They grew at different rates and to different extents. After 94 heats they reached a constant volume. The growths varied between 35.21 per cent and 37.50 per cent. An increase in weight was found in all cases.

The authors solved the practical problem to find an alloy whose volume remains constant even after repeated heatings at about 900° C. Such an alloy is a white iron with about 3 per cent of carbon and only small quantities of other constituents, of which, for the purpose, silicon is the most important and should not exceed about 0.2 per cent to 0.3 per cent.

The growth of the cast iron is intimately connected with the presence of graphite and silicon. Gases also play an important part. In some cases the growth in air on heating is entirely due to oxidizing gases penetrating the interior, while in other cases gases originally dissolved in the iron contribute to some extent to the growth.

The authors finally apply their results to explain the mechanism of the growth of annealing ovens and other cast-iron vessels in ordinary practice. These ovens are grey irons. They contain graphite and silicon. They contain some dissolved gases, and they are exposed in practice to the direct action of flame gases. They consist of four main structural constituents, which may almost be considered as three.

1. A solid solution of iron silicide in iron and manganese.
2. Graphite.
3. Some combined carbon-pearlite.
4. Phosphide eutectic.

With repeated heating 3 tends to pass into 2. Only 1 and 2 will be considered.

After the first heating, gases have penetrated to a certain depth. The authors' view is that, although the gases penetrate to a certain depth during this period, possibly along slits existing between the graphite plates and the solid solution of silicide in iron, and through holes which exist here and there, yet they are not actually absorbed by the solid solution until the oven is cooling. During this absorption the oxides of carbon oxidize the iron silicide, in the first instance, at the boundaries of the crystals. This reaction is accompanied by growth and incipient disintegration. Minute cracks are formed. There may be a series of minute explosions, owing to the reaction between the dissolved hydrogen and the penetrating oxides of carbon. The mechanically weak graphite may be disintegrated and forced into holes originally existing in the metal. Nitrogen enters along with the oxides of carbon, and is absorbed to some extent. The net result is a slight growth of the oven by the time it has cooled to the ordinary temperature.

When the oven is next heated, the furnace gases penetrate a little farther, owing to the fresh avenues opened up by the reactions just described. On cooling these reactions are repeated, and in this way more of the iron is disintegrated and a further growth takes place. Simultaneously, if the iron is close-grained, hydrogen and nitrogen are liberated in the interior at the boundaries between the solid solution and the graphite. Their coefficient of expansion is so much greater than that of the solids that they exert a considerable pressure, with the result that the mechanically weak graphite is disintegrated, and appears to collect in the holes of the casting. Where the boundary between two holes consists of graphite, it is destroyed by this action, and the two holes become one.

As the heat progresses these changes continue. After each heat the external gases have penetrated a little farther. Finally, they work their way right through the oven, the rate depending on its chemical composition, physical texture, etc.

When this condition is reached the oven has grown to its full extent. Some of the graphite has been burned off, all the silicide of iron has been oxidized, probably to a mixture of iron oxide and silica, and some iron has been oxidized as well. The main cause of the growth is the disintegration of the material caused by the oxidation of the iron silicide. In close-grained irons the pressure of dissolved gases also contributes to the growth. At the conclusion of the process the structure has been revolutionized; the oven has lost the properties of cast iron. It has no mechanical strength, and can be sawn like a piece of chalk.

The authors have no hesitation in recommending that white irons should be tried for annealing ovens instead of grey. The most suitable composition appears to be an iron with about 3 per cent of carbon and as few impurities as possible. Of these silicon is the most important, and should not exceed 0.2 per cent to 0.3 per cent. This iron would probably shrink slightly on repeated heating. The reason why an upper limit of 3 per cent of carbon is suggested is that white iron higher in carbon will tend to deposit temper carbon. Where this is the case, the material will begin to grow. Even so, however, the growth will never be as much as in a grey iron. It is possible that an oven constructed of white iron may prove to be unsuitable, because it may crack on heating. Should this difficulty arise, it may perhaps be overcome by modifying the design.

Permanent Way of British Railways.

Mr. R. Price-Williams presented a paper on "the serviceable life and cost of renewals of permanent way of British railways." According to the Board of Trade Railway returns (1907), there are, roundly speaking, a little over 23,000 miles of railway open for traffic in the United Kingdom, of which about 13,500 miles consist of double and more lines and about 10,250 miles of single lines, besides which there are 14,000 miles of sidings.

The total annual cost of the maintenance and renewal of the permanent way and works amounted to roundly £11,000,000 sterling, nearly 15 per cent of the entire working expenses which have now and for some years past reached the exceptionally high figure of nearly two-thirds (63 per cent) of the entire railway gross receipts.

The average cost of renewals per mile varies from an average maximum of £418.18 per mile during the 10 years, in the case of the London, Brighton & South Coast Railway, to a minimum of £190.80 per mile in the case of the North British; while the tonnage of goods and minerals per mile in the latter case is just double that of the London, Brighton & South Coast.

Evidently, the tonnage of freight alone does not account for the exceptionally large cost of renewals of the permanent way of some of the prominent British railways; the principal additional factor is probably the greatly increased weight and speed of the passenger traffic which was made possible by the introduction of Bessemer steel rails in the early sixties of the last century. It is interesting to compare the cost of renewal of the iron rails before that date and of the steel rails afterward.

The total cost of the renewal of nine principal railways with iron rails during the 18½ years prior to 1865, with an average aggregate of 3401 miles of way during that period, only amounted to £5,796,135 and to an average of £170.40 per mile of way. It rapidly increased during the first 10 years after the first partial introduction of steel rails to £285.53 per mile, partly owing, no doubt, to the high price then of steel rails. Notwithstanding the great subsequent reduction in the price of steel rails to a lower figure than even the best iron rails, the expenditure in the renewal of way on these nine principal railways has, however, now reached an amount of £28,101,881 and £314.66 per mile of railway during the short space of the last 10 years—a fivefold increase in amount and now double the cost per mile in renewals—the mileage of these nine railways having increased from 3401 to 8930.

While the mileage during the last 47 years has only a little more than doubled, the working expenses have increased nearly sixfold; the number of passengers carried has increased nearly sevenfold, the tonnage of goods and minerals carried has increased nearly fivefold, while the number of carriages and wagons has only increased three fold; no doubt a considerable portion of the increase of the permanent way expenses is mainly due, as already stated, to the very large increase in the weight and speed of the passenger traffic, and partly to the very large increase in the tonnage of goods and mineral traffic, and also in some degree to its somewhat increased speed.

That the much greater strength and durability of the high-class of steel material, of which Bessemer steel is the type, has largely contributed to the exceptionally rapid growth, not only of railway traffic in this country, but of its trade and commerce generally, there can be no question.

In the second part of the paper the author gives detailed data illustrated by diagrams of the cost of maintenance and renewals of the permanent way of 15 principal British railways in the last 10 years with an aggregate of 15,184 miles of railway. In the average 504 miles had been worn out per year and have been replaced in the most, if not all, cases with stronger and better materials, and as the traffic on these railways is still rapidly increasing, it may be estimated that at least that quantity of worn-out steel rails will have to be simultaneously renewed during a similar period in the future in Great Britain.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

Iron and Steel Institute.

The autumn meeting of the Iron and Steel Institute was held at the Institution of Civil Engineers and extended over three days, instead of two, as formerly, for the reading and discussion of papers. Lord Airedale presided on the opening day, Sept. 28, and the president, Sir Hugh Bell, occupied the chair during the remainder of the proceedings. The Carnegie gold medal was presented to M. A. Portevin on the second day. Abstracts of the papers presented will be found elsewhere in this issue. The discussions, generally, were wanting in animation, and, owing to lack of time, some papers of considerable interest—e.g., "The Constitution of Carbon-Tungsten Steels," by Mr. T. Swinden—were simply taken as read.

The reading of Herr E. J. Ljunberg's paper on **"The Production of Iron and Steel by the Electric Smelting Process"** evoked from Mr. P. R. Cobb the remark that the author's statement that no advance had been made, for commercial purposes, in the use of the electric furnace for iron-ore reduction was not in accordance with the fact that contracts for the erection of three new electric furnaces at Sault Ste. Marie had just been placed. He asserted that the opinion of the Canadian iron and steel men was very favorable to the electric furnace. By the middle of next year these Canadian reduction furnaces, producing silicon pig iron, ought to be running, and valuable commercial data would be furnished from the results of their operation.

Lord Airedale pointed out that many available sources of water-power in England were neglected, and that relying so much on coal power was not favorable to progress with the electric furnace.

The discussion of Mr. C. A. Ablett's paper on **"The Determination of the Economy of Reversing Rolling Mills"** was opened by Mr. Andrew Lamberton, who contended that the author had not adduced proof of the claims put forward for economy. A statement of cost expressed in kw-hours was academical, and steel makers wanted cost put commercially in pounds, shillings and pence. He had personally gone into the question and worked out the cost of production of a ton of rails with a plant turning out 300 tons in 10 hours, and found that with steam power—allowing 10 per cent for interest and depreciation—the cost was 5d. per ton, while with electrical power—allowing 15 per cent for interest and depreciation—the cost was 8.8d. per ton.

Lord Airedale considered that the electrically driven rolling mill had advantages for intermittent working where power was derived from an outside source.

Mr. Alexander Siemens quoted the old saying, "those are most deaf who do not want to hear." There was no difficulty in converting kw-hours into cost in money; and lengthy experience in working a 1500-hp or 1600-hp generating plant at his own works gave an average of ¼d. per kw-hour. The allowance of 15 per cent was not justifiable with properly selected plant. Many persons did not recognize the fact that it was cheaper to run big motors than small ones; and he called to mind a case in which, when, on his recommendation, a motor was replaced by another twice its size, surprise was expressed that the big machine consumed only half as much current as the small one. Current depended on the load, not on size of motor. His plant was as good now as when put down 20 years ago because it was kept within its power. If, said the speaker, you are advised to put down a 10-hp motor, then put in a 15-hp machine instead.

Mr. Ablett replied that at the Rhenish Stahlwerke a saving of 1 shilling per ton had been effected on an output of 5000 tons per week, and the oil consumption had been reduced by one fifth. As to depreciation, the Niagara Falls Power Company started a 5000 hp plant 14 years ago, and the only repairs that had been necessary were rewinding after 10 years' running and manifestly 15 per cent was far too high an allowance.

The paper by Professors H. F. Rugan and H. C. H. Carpenter on **"The Growth of Cast Irons After Repeated Heatings"** having been read, Mr. J. E. Stead said the paper added much to our knowledge of the subject. It had long been known that white iron did not grow so rapidly as grey iron, and white iron—furnace bars, for example—repeatedly

heated and cooled did not oxidize so rapidly as grey iron. Oxidation of grey iron followed along the graphite plates, which with every successive heating became more and more separated from the metal and thus permitted the passage of oxygen. As white iron contained no graphite, oxidation from such cause could not occur. He considered that with a greater percentage of combined carbon the oxidation would be less.

Professor Turner remarked that some years ago he had noticed much growth in the grids of muffle furnaces. He felt sure that the methods adopted by the authors were worthy of Dr Carpenter's name. Whenever a constituent of an iron alloy separates out there is always an increase in the volume. He quite agreed that so long as iron remained white there would not be any expansion, but as soon as graphite is deposited expansion commences. In the growth oxidation occurs, and then we had ferric oxide and silica side by side. It was possible thus to obtain pure silica from silicon. He was inclined to regard the expansion as analogous to that of lead roofing on a sloping surface. If we imagined the iron to be in a soft state surrounded by a hard oxidized skin, it would be apparent that the iron would expand when heated, but could not contract to any great extent on cooling.

Mr Saniter was interested more particularly with steel. He wished to point out that the sample referred to in Table 8 did not increase or decrease to any extent with repeated heatings. Rolled steel shortens as the result of repeated heatings in consequence of the elongated grain produced by rolling, returning to a shorter, rounded shape. The point which required explanation was: Why did alternate heatings and coolings cause growth? He thought that each consequent separation of impurities in crystalline form on cooling each time prevented contraction.

Dr Rosenhain had found that in the case of white iron there was no growth until after separation of graphite had occurred. He thought that it would be very instructive to ascertain the rate of deterioration of the mechanical properties of iron as growth progressed.

The papers by Mr. Greville Jones on **"Uniform Moisture in Blast"** and by Mr. R. S. Moore on **"The Fuel Economy of Dry Blast as indicated by Calculations from Empirical Data"** were discussed together.

Mr Martin said he had experienced a very great saving in coke by the use of the Gayley dry-blast system. He desired to state that his results had not been obtained in the blast furnaces only.

Mr. J. Harrison considered that further experiments were desirable to shed more light on the subject. Moisture could be reduced from 4 grains per cubic foot to 2 or 2¼ grains by cooling by means of ordinary water, and the reduction effected considerable economy.

Mr. Reece remarked that Mr. Moore's experiments seemed to prove what he has disproved. Increase of moisture was unquestionably prejudicial, and he asked whether benefit did not arise from mere uniformity. An experiment quoted showed results equally good with an increase of moisture as when its amount was smaller. At South Chicago twice as much moisture was removed as at Cardiff, yet results at Cardiff were as good. Therefore, what else but uniformity produced equally good results?

Mr Foster wished to ask how the total calories given on page 8 of Mr. Jones' paper were arrived at.

Mr. Sterne vouched for the accuracy of the figures relating to dry-air blast. The resulting economy would recoup the cost of the dry-air blast plant in from 18 to 24 months.

Mr Rogerson asked why the Steel Corporation used only one furnace with the dry-air blast.

Mr. Reece replied that they had three, and were putting down three more.

Sir Hugh Bell said he had once been told by a friend that it took £10,000 and 10 years to make a chemical experiment. He wished that all experiments demanded no greater expenditure of time and money. The final solution of the questions raised was not yet arrived at; and Mr. Reece's observations pointed to the desirability of further investigation. Yet reports from South Wales and elsewhere showed considerable economy resulting from the dry-air blast.

Mr. F. J. R. Carulla's paper on **"Artificial Magnetic Oxide of Iron"** was then read.

Professor Turner said that oxide of iron might still be magnetic, although varying from the formula Fe_3O_4. He had found by experiment that the proportions of ferrous and ferric salt could be varied considerably and yet the oxide obtained would be magnetic. He had had for analysis a sample of what was really magnetite, but the proportion of ferrous oxide was very small.

Dr. J. N. Friend's paper on **"The Corrosion of Iron"** followed, but there was not any discussion thereon.

The president remarked that whether the electrolytic theory or the acid theory were correct—and it was not improbable that both actions went on—the question of corrosion had become of supreme importance now that iron and steel were being used in large and increasing quantities for building construction. The attainment of the fullest possible knowledge of the subject was requisite, and any contribution to that end was valuable.

The papers read on the concluding day were those by Mr. R. Price-Williams on **"The Serviceable Life and Cost of Renewals of Permanent Way of British Railways,"** and by Mr. E. Adamson on **"Tests of Cast Iron."**

The discussion on the former of these was prolonged, but yielded but little of metallurgical interest, and related chiefly to comparisons of cost, weight of vehicles, etc., now and in 1860.

Mr. T. Hurry Riches said Mr. Williams had not made much allusion to quality of steel or sections of tires now and years ago. The tire section had a decided influence on the life of the rail. There was, fortunately, now more co-ordination between permanent way engineers and rolling stock engineers to adapt rails and tire sections to each other; and he hoped that the author's paper would tend to effect further improvement in this direction.

The president, in the course of his remarks, said the material, form and nature of running of tires had become matters of constant criticism. Rail makers had to be subject to various tests, and often had demands for contradictory qualities. He had taken a prominent part in producing rails of special hardness necessitated by modern brakes. The questions raised by the author were of vital importance to the country at large.

Prof. H. Lewin hoped that curves of circular radius would be replaced by the paraboloid form.

Speaking on Mr. Adamson's paper, Professor Turner asserted that rectangular test bars gave irregular results, and the utmost care was necessary to get a straight pull. Bars with the skin on gave high results, but were not so trustworthy as machined pieces. If test pieces were cast with the fin downward, higher figures were obtained. With regard to ferro-silicon, he had not advocated its use nor found it really advantageous, although it appeared that good results had been got by its addition just before pouring. If added at the right time and in the right amount, then well and good; if not, it were best left out.

Mr. Adamson replied that he believed higher results were obtained from machined bars, and that many results from unmachined bars might be termed "flukes." His experience was that only 20 per cent of the ferro-silicon used found its way into the iron. It was a very expensive addition.

The president characterised a "fluke" as something which we could not explain. He hoped that the author would soon be able to tell us there were no flukes.

The Separation of New Radio-Active Disintegration Products.

Dr. Otto Hahn, in his paper read before Section A of the British Association, at Winnipeg, remarked that Rutherford and Soddy's disintegration theory had resulted in the recogni-

tion of a considerable number of radio-active products, differing in chemical and physical properties, and separable by appropriate methods. Some emit α particles, some emit β particles, some emit both, and others appear not to emit any particles. The speed at which the α particles are emitted for any particular product is definite and characteristic for that product; but this does not appear to be the case with β rays, the absorption curves for which are complex in some cases and indicate β rays of a complex nature, while in other cases they show only rays of one type. Two years ago the author and Dr. Lise Heitner undertook a comparison of all the various β ray products under identical conditions, and they have now advanced the hypothesis that radio-active products consisting of a single substance emit radiation of one type only—either homogeneous α particles or homogeneous β particles. If this be true, then all substances emitting both α and β rays or complex β rays are of diverse composition and may be separated into at least two constituents. The active deposit of thorium was found to be composed of four different substances, the fourth of which had not previously been recognized, and emitted β rays hitherto attributed to thorium C. Similarly, the radio-active deposit of actinium contains three constituents, of which the third emits β rays previously considered as proceeding from actinium B. Thorium D has a life period of three minutes, and actinium C has a life period of 5.1 minutes.

In the case of radium there appear to be single β rays from the B substance and complex rays from radium C, which latter is, hence, probably of complex constitution and has three constituents, one α and two β ray substances. The "recoil method" of separation of the radio-active disintegration products was resorted to. Radium C yielded feeble results. If the α rays be emitted from the last product of radium C, then this probably consists of three products, one enduring 19 minutes, one with a period of one to two minutes, and the third having a very short life. Recent experiments appear to indicate that radium itself consists of two different substances, the second of which may be provisionally designated radium x and emits the familiar α particles, while the pure radium only gives out β rays, which are absorbed with facility.

London, September, 1909.

SYNOPSIS OF PERIODICAL LITERATURE.

Copper.

Corrosion of Copper and Brass.—At the recent Manchester meeting of the (Brit.) Institute of Metals, Mr. E. L. Rhead discussed some causes of the corrosion of copper and brass. Copper and copper zinc alloys in contact with saline solutions such as sea water corrode in a peculiar manner. Brass condenser tubes exhibit deep pits on the side next the water. These often occur in lines. In other situations and under other conditions copper enrichment takes place. The pits in the case of condenser tubes are commonest on the side of the tube lying undermost when the tube is in position. This corrosion is most erratic. It is generally attributed to selective chemical action, and to electrolytic effects due to the duplex structure of the alloy. In the experiments mentioned in the paper samples of hard copper and brass were submitted to corrosion in various saline solutions and their behavior noted. Some of the solutions were saturated with carbonic acid gas. The figures obtained showed the greater tendency of the hard material to corrode. The edges and parts of brass plates that were scratched showed deposition of copper. Strips of hard brass were softened at one end and bent into U shape. When the free ends were put into corroding solutions the hard limb dissolved more extensively and rapidly than the soft limb, the hard metal appearing to form an electric couple with the soft metal. Corrosion occurred in lines parallel with the direction of rolling. The surface of the hard metal was made very rough and irregular. That of the soft metal remained smooth. These roughnesses may form points from which the disengagement of gases dissolved in water flowing through condenser tubes may take place, thus facilitating the pitting and hastening the corrosion and failure of the tube. From this it would appear that the final cold drawing of a tube to produce stiffness is liable to produce irregularities that may increase the rapidity of attack. (From advance sheets.)

Zinc.

Pure Spelter.—At the recent Manchester meeting of the (Brit.) Institute of Metals, Mr. John S. G. Primrose presented a paper on the production of pure spelter. After briefly reviewing the important commercial position of zinc and the existing methods of refining the metal, Mr. Primrose discussed the theory of the new process of purification by fume filtration during distillation. Lead is sensibly volatile below its boiling point in presence of zinc vapor and passes out of the retorts in a state of gaseous solution in the zinc, and the repeated infringement on the surface of the filter material dissociates the alloy, allowing the zinc to pass on to the condenser almost pure, but retaining the lead chiefly in the metallic condition and recoverable in this state. He shortly described the plant at Irvine Spelter Works and detailed the working of dross refining, which yields 99.8 per cent spelter from very impure material in one step.

The chief item of the paper was the description of recent experiments on the direct smelting of Broken Hill middlings, which gave most remarkable results and showed clear indication of a solution of the long-standing problem. The process is admirably suited for the commercial production of the highest grade spelter from this class of material, and although the tests were carried out in large furnaces of six or seven tons daily capacity, there is no reason why it should not be applied to furnaces of any existing capacity. It is most creditable that in the second run of only three days, two thirds of the output was of 99.5 per cent purity and the remainder averaged 99.1 per cent zinc, particularly with over 13 per cent of lead in the middlings. The zinc smelting loss sustained on the average for the three days working in September was only 10 units, which is less than in ordinary practice, and that in spite of the fact that hand made retorts were used. With denser machine-made muffles the loss should show a decided decrease. Of the lead in the middlings over three fourths was retained in the residues as metallics, which further held 95 per cent of the total silver content of the charge. Quite 10 per cent of the lead was recovered from the filters in the metallic condition, and assayed 10 oz. of silver per ton. Besides these enormous advances in working, the process possesses the further advantages of being extremely simple, since the filter is a purely mechanical contrivance fixed between the retort and the condenser and not disturbed during the day's maneuvre. It has a wide range of usefulness and is easily adaptable to any class of material used, particularly if it is impure, and the extra cost of production amounts only to a few pence per ton of spelter. (From advance sheets.)

Alloys.

Aluminium-Copper-Tin Alloys.—These tertiary alloys were the subject of a paper by C. A. Edwards and J. H. Andrew, read at the recent Manchester meeting of the (Brit.) Institute of Metals. Many of the industrial non ferrous alloys contain more than two metals. These mixtures have been arrived at by the method of trial and failure, and, as a consequence, possess in a more or less degree the required properties for their particular purpose. This method of working was the only one available up to a comparatively recent date. But now, with the aid of the microscope and pyrometer, the constitution of alloys can be determined, and from such data the properties and correct heat treatment deduced.

Very little is known of the constitution of alloys containing

more than two elements, therefore, it cannot be said that the ternary alloys in use are the best possible mixtures of their components.

The conclusions arrived at by the authors were as follows:

No ternary compound is deposited from the liquid alloys.

No ternary eutectic is formed.

Judging from the constitution and appearance of the alloys it is clear that those possessing reasonable mechanical properties are confined to two very limited areas, viz: those containing upward of 86 per cent of copper, and those which contain more than 85 per cent of aluminium.

Viewed from a theoretical standpoint no advantage is to be gained by adding tin to those alloys containing about 10 per cent of aluminium and 90 per cent of copper.

The authors think it probable that an alloy containing about 6.5 per cent aluminium, 5.5 per cent of tin and 88 per cent copper will have the same properties as an alloy containing 10 per cent of tin and 90 per cent of copper. Such a ternary alloy would be cheaper than the copper-tin, and would have a lower specific gravity.

Alloys containing the compound $CuAl_2$ with tin may be found of use as bearing metals, for when made under certain conditions they consist of a very hard constituent embedded in a soft matrix of tin. (From advance sheets.)

Miscellaneous.

Specific Heats of Silicates and Platinum.—In the *American Journal of Science* for October, W. P. White gives an account of a new determination of specific heats of silicates and platinum. For determining the specific heats of silicates up to 1500° C., the method of mixtures, in which the heated substance and containing crucible are dropped from a furnace into a calorimeter at room temperature, was selected as the most accurate.

All measured temperatures, including that of the calorimeter, were read by thermo-elements. By this means rapidity and simplicity of manipulation were secured. A consideration of the various sources of error indicates for the mean specific heats a final accuracy of better than 0.5 per cent at most temperatures. The true specific heats, derived from these, are less accurate.

The chief numerical results are given in the following two tables:

TABLE I.

Mean specific heats from zero, of platinum, pseudo-wollastonite, wollastonite, orthoclase, diopside, quartz, orthoclase glass, and a soft tubing glass.

Upper temperature.	Pt.	P. Woll.	Woll.	Or.	Di.	Qu.	Or. glass.	Soft glass.
100°	.....	....	.1833	.....	.1919	.1840	.....	.1977
	.....	....	.1833	.....	.1905	.1851	.....	.1974
	.....	.....	.....	.....	.1920	.....	.....	.....
500	.03348	.2159	(.2180)	.2248	.2310	.2372	.2291	.24000
	.03355	.2169	.2169	.2246	.2308	.2368	.2304	.24077
	.....	.....	.2168	.....	.....	.....	.....	.24137
	.....	.....	.....	.....	.....	.....	.....	.24107
700	.03423	....	.2286	.....	.2420	(.2547)*	.....	.2646
	.03428	....	.2289	....	.2422	.2559*	....	.2639
	.....	.....	.....	.....	.....	.2556*	.....	.....
800	.....	.....	.....	.2401	.....	.....	.2465	.....
	.....	.....	.....	.2402	.....	.....	.2473	.....
900	.03515	....	.2354	.....	.2409	.2597*	.....	.2791
	.03514	....	.2355	.....	.2488	.2594*	.....	.2796
	.....	.....	.....	.....	.2483	.....	.....	.....
100	.03573	.2380	(.2423)	....	.....	.....	.....	.....
	.03578	.2380	.2404	.2505	.2562	.2643*	.2588	.2907
	.....	.2375	.2404	.2513	.2564	.2646*	.2591	.2909
	.....	.....	.2403	.....	.....	.....	.....	.....
300	.03646	.2422	....	.....	(.2613)	.....	.....	.2945
	.03647	.2416	....	....	.2596	.....	.....	.2949
	.....	.....	....	....	.2601	.....	.....	.2972
	.....	.....	.....	.....	.....	.....	.....	(.2996)
1500	.03675	.....	....	....	.....	.....	.....	.2999
	.03682	.....	....	....	.....	.....	.....	.2998
	.....	.....	.....	.....	.....	.....	.....	.3024

*Affected by the inversion at 575°. †Heated by lead bath.

TABLE II.

True specific heats of substances given in the preceding table except quartz.

Temperature	Pt.	Woll.	P. Woll.	Or.	Di.	Or. glass.	Soft glass.
500	.0356	.251	.250	.257	.262	.264	.298
700	.0368	.263	....	....	.272	....	.324
800	.....	.....	.....	.272	....	.282	....
900	.0380	.262	....	....	.281	....	.340
1100	.0390	.261	.259	.279	.286	.297	.335
1300	.0400	...	.257	....	.278	....	.333
1500	.0407	....	....	....	....	....	.332

RECENT METALLURGICAL AND ELECTROCHEMICAL PATENTS

Electrochemistry.

Electric Furnaces.—It is a well-known fact that the efficiency of an electric furnace can be increased by heating the outside walls, because the heat loss through the walls is thereby reduced on account of the reduced temperature drop in the walls. Mr. W. Acheson Smith, of Niagara Falls, N. Y. (International Acheson Graphite Company), makes use of this principle in a simple way in such cases where combustible gases are given off from the charge, such as carbon monoxide, hydrogen, hydrocarbon vapors, etc. Such gases are given off, for instance, from the charge in carborundum or graphite furnaces. Mr. Smith makes the walls permeable by providing channels in the same through which the vapors may escape. Provision is made to concentrate the heat obtained from the

Fig. 1.

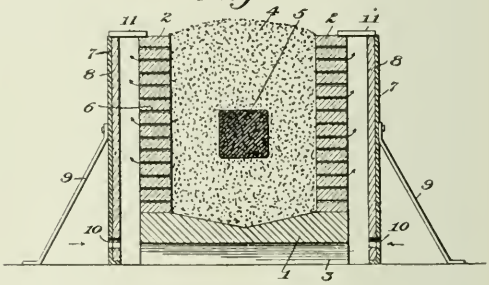


FIG. 1.—REDUCTION OF HEAT LOSS FROM ELECTRIC FURNACE

burning gases in next proximity to the walls. In Fig. 1 this is done by means of the heat-retaining walls 7 spaced from the permeable walls 2. These heat-retaining walls 7 are of sheet metal with an interior lining of a material of low-heat conductivity 8. Air in excess is admitted to the space between the permeable walls 2 and the heat-retaining walls 7. Modifications of this construction are also described. The effect of this construction is a double one. Since the rate of flow of heat from the charge through the walls is reduced, a considerable economy of energy consumption is effected in maintaining any given temperature or range of temperature in the charge. Secondly, in the production of materials requiring more or less definite temperature conditions, as, for instance, carborundum, the productive zone of the furnace is greatly extended. The result is therefore not only increased economy of energy consumption, but increased output in pounds. (935,937, Oct. 5, 1909.)

Carborundum.—While in the classical Acheson process of manufacture of carborundum a resistance furnace is used, Mr. F. J. Tone (Carborundum Company) has found that an arc furnace has certain advantages if it is desired to produce carborundum of a dense compact variety with great toughness. The charge surrounds the electrodes, the arrangement being otherwise the same as in another. When the arcs are started in the usual way, that part of the charge within the arc zone and below the electrodes is converted into silicon carbide, and by raising the electrodes from time to time the finished product builds up to any desired height. Fresh mixture is added around the electrodes from time to time as the charge under treatment is converted into silicon carbide. If it is desired to run the furnace continuously, the finished product may be withdrawn from the column which has built up under the electrodes at the farthest point from the arc zone continuously or intermittently, without shutting down the furnace or disturbing the mass in the vicinity of the reaction zone. One of the advantages of this method is that when the charging mixture contains constituents which make it more or less conductive, such as coke or sand

having high percentages of impurities, or when the mixture contains "white stuff" (which term is applied to the partially converted mixture of a silicon carbide furnace which has already been used in the process), the area of the reaction zone is thereby increased and rendered more efficient. (937,119, Oct. 19, 1909.)

Silicon.—In certain electric furnace processes it is important to remove as quickly as possible the products of reaction from the reduction zone. This is, for instance, the case in the production of silicon and silicon alloys. F. J. Tone carries out such a process in an electric furnace, as shown in Fig. 2. The hearth 2 of the furnace is formed of carbon or graphite, while the side walls 4 are of a non-conducting refractory material. The charge rests upon a hearth 8 which ex-

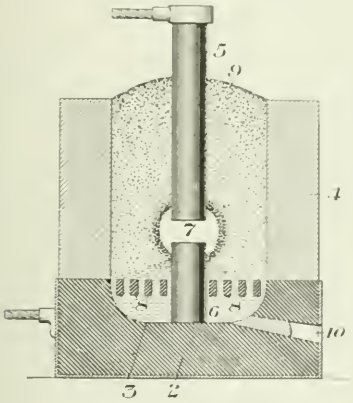


FIG. 2.—SILICON FURNACE

tends over the collecting receptacle within the terminal 2 and in the form shown is composed of horizontally extending carbon bars, which are suitably supported in or on the side walls. These bars are spaced apart a proper distance to allow the molten products to drop between the hearth so formed, while this hearth supports the charge and is practically impervious thereto. The charge is indicated at 9, and fills the space around the upper electrode. The intermediate hearth is placed between the reduction zone of the arc and the receiving space at the base, and is sufficiently elevated above the base to give a receptacle of the desired size. From this receptacle the product may be tapped out through the taphole 10. In the operation of the furnace, the charge is supported upon the hearth through which the products drop from the reduction zone into the receiving space. The products are thus not liable to be contaminated by the charge, which is kept apart by the hearth which supports it. (937,120, Oct. 18, 1909.)

Magnesium.—F. von Kugelgen and G. O. Seward (Virginia Laboratory Company) who have done considerable work in the past on the electrolytic production of magnesium, chromium, etc., have patented a new process for the production of pure magnesium. It consists of two steps which are carried out in two different vessels. The first step produces an alloy of magnesium with a less electro-positive metal (aluminium) by electrolyzing a molten magnesium electrolyte with an insoluble anode and a cathode of a molten metal less electro-positive than magnesium (like aluminium). The second step produces pure magnesium by consecutive dissolution and deposition from such alloy, the latter being used as the anode in a suitable electrolyte. In the first step any less electro-positive metals than magnesium, which may be present as impurities in the initial electrolyte, are separated together with the magnesium and are absorbed by the molten alloy of the cathode. In the second step these impurities, being less electro-positive than magnesium, are not dissolved therewith, but remain in the molten anode, pure magnesium being thus produced. In the first step an electrolyte of low specific gravity is used so that an alloy very rich in magnesium can be produced without danger of its leaving its position at the bottom of the electrolytic vessel. In the second step an electrolyte is used of sufficiently high specific gravity to insure the rapid flotation of the magnesium to the surface as soon as deposited and its collection there. Molten aluminium forms the cathode in the first step and a molten alloy of aluminium and magnesium the anode in the second step. The molten electrolyte in the first step is preferably $MgCl_2$ + KCl with carbon anodes and a cathode of molten aluminium. The magnesium produced at the cathode alloys with the aluminium. As the electrolysis proceeds the alloy becomes richer in magnesium; when it contains from 50 to 60 per cent of magnesium, it is removed either in whole or in part and is used as the anode in the second step of the process. The electrolyte in the second step may be similar to that in the first step excepting that a certain proportion of a heavy salt of a more electro-positive metal than magnesium (e.g., barium-chloride) is added to increase the specific gravity and to facilitate the flotation of the magnesium. As magnesium is dissolved from the anode to the same extent as it is deposited at the cathode, the electrolyte in the second step of the process remains substantially unchanged. Magnesium, being the most electro-positive constituent of the molten anode in the second step of the process, is alone dissolved and redeposited, care being taken to avoid exhausting the anode too much of its magnesium content. For this purpose a large part of the magnesium which forms the cathode in the second step is removed from time to time and most of the nearly exhausted alloy of the anode is tapped and replaced by a rich alloy from the first step. (935,796, Oct. 5, 1909.)

Diaphragm for Electrolytic Cell.—A practically non-conducting carbonaceous diaphragm is made by Mr. I. L. Roberts as follows: The diaphragm is first cut into the desired form from wood, or molded into the desired form from wood pulp, etc. It is then placed in a suitable oven and heated very slowly, keeping the temperature as nearly as possible uniform throughout all parts of the vessel. The heating should be carried only to such a degree that the diaphragm will be charred without becoming conductive to any appreciable extent. If the diaphragm is made from wood of a good quality that is of even grain, free from cracks, etc., it will retain its form very closely. If it is to be in the form of a flat plate or sheet and is made from wood pulp, etc., it must be prevented from warping or twisting in the process of carbonization, and for this purpose it is clamped between a pair of iron plates during the baking, perforations being provided in the clamping plates to permit escape of the gases due to decomposition. If the heating is not carried too far, the conductivity of the diaphragm will be sufficiently poor to prevent its action as a bipolar electrode used in the electrolytic cell. (936,439, Oct. 5, 1909.)

Iron and Steel.

Electric Steel Refining.—Mr. O. Thallner, who has had an extensive experience with the Heroult steel furnace in Bismarckhütte, Germany, patents the following process of producing steel free from oxides. The application of silicon for the deoxidation of steel and slag is well known. In treating steel for rolling it is added to the molten metal before or during tapping. In both cases the silicon effects deoxidation by reducing the protoxides of iron or manganese present. The silicon is not only used as in this action, but there remains also a considerable quantity of the products of the reduction, for instance, silica, and in such a fine state of division emulsified in the metal, that it is not capable of separating out in the short time before pouring. The result is that only a small quantity of the pure silicon remains in solution in the steel and as this small quantity only acts for a short time it has

practically no influence on the internal structure of the steel. On the contrary, the fine emulsified silicic acid has a disadvantageous action on the internal structure. If it is desired to cause the silicon to act advantageously on the internal structure the metal must contain a greater quantity of the silicon and be subjected to the protracted action of the silicon at the melting temperature.

It is known that in the Martin furnace a strong blowing action is obtained in consequence of the gases of combustion. That is to say, there is a constant excess of oxygen present in the slag, and this oxygen has a constant blowing action on the metal bath below it. It is, therefore, impossible to obtain a constant percentage of carbon in the metal in a basic-lined furnace of this kind as the carbon is in contact with the slag which is rich in oxygen and is subjected to constant changes, as also is the manganese in the metal bath. This oxygen, of course, also affects the silicon, as the silicon has a great affinity for the oxygen in the slag, and passes over the slag as silicic acid. It appears, therefore, to be impossible to retain pure silicon dissolved with a basic-lined Martin furnace and it appears also impossible to obtain a favorable action of the silicon on the internal structure of the steel.

There still remains the possibility of adding the silicon before tapping or in the ladle. Silicon, of course, always reduces the protoxide of iron and manganese out of the slag in a Martin furnace. The object aimed at, however, was difficult to obtain, as the metal below the slag might still remain rich in oxygen and in addition very large quantities of silicon were necessary to bring about the permanent silicizing, as the slag constantly took up oxygen from the combustion gases and this oxygen had to be continuously removed. The slag was, therefore, always more acid in its nature and increased in its tendency to give up oxygen to the metal bath. It may be, therefore, assumed as a practical impossibility to melt metal in a basic flame-heated furnace, and still retain a reasonable proportion of silicon in solution.

Mr. Thallner discovered that the protoxides may be removed and pure silicon taken up in solution by the steel by treating blown steel in an electric furnace with a basic lining and heating the steel together with silicon in said furnace. The electric furnace with a basic lining in consequence of the high temperatures obtained retains the slag in a much more basic character than was at all possible in a Martin furnace. The consequence is that the slag is less liable to take up oxygen from the air as there is no oxidizing flame present in the electric furnace. The proof of this may be found in the fact that the metal may be heated for several hours in an electric furnace with a basic lining without altering the percentage of carbon and manganese in the metal. The proof is also to be seen in that the slag may be retained free from iron for several hours. This circumstance alone permits the carrying out of the following process.

The Martin steel or the melted product from any other blowing apparatus is passed into a basic electric furnace. Sufficient ferro-silicon is added, either in the electric furnace or when tapping into the ladle, to completely deoxidize the metal so that a fixed amount of pure silicon remains in solution. When added in the electric furnace the ferro-silicon may be laid in the furnace and the metal poured thereon or the ferro-silicon may be thrown on the top of the metal bath before the lime is added for forming the slag. The chemical action which results is as follows: The product of the deoxidation which is emulsified in the metal has time during the melting in the electric furnace to separate out and this product passes in the form of silicic acid into the slag. The pure silicon held in solution is neutral as regards the basic lining. In consequence the basic lining of the furnace is not attacked, whereas the excessive addition of silicon on a basic Martin furnace led to the formation of large quantitiees of silicic acid which attacked the lining of the furnace very severely. If the slag in the electric furnace still contains iron-protoxide, the iron in the slag is gradually extracted by means of the silicon in the bath, and this reduction takes place at the contact surface between the slag and the metal bath. The reduction further takes place until the whole content of silica has been used up or until the slag is free of iron. In order to retard the loss of silicon it is necessary to accelerate the deoxidation of the slag. This may be effected by throwing on charcoal or the like, or aluminium compounds, or even pulverized ferro-silicon. When the deoxidation is complete in the slag, it becomes white or falls to a powder when exposed to the cooling action of the air. When the slag becomes white or falls to a powder in the air, the metal bath below the slag may be assumed as in a proper state for taking up pure silicon, and that the silicon remaining in solution in the metal will no longer be used up. In consequence, if further additions of ferro-silicon are made, the silicon acts on the internal structure of the metal so that the resulting product is just as fine in grain and as tough as if the metal had been treated in an acid-lined electric furnace or in a crucible. This is really the novel technical effect obtained by the invention, viz., to bring about the permanent action of the pure dissolved silicon on the internal structure of the steel in a basic-lined furnace. (937,486, Oct. 19, 1909.)

Copper.

Brass and Bronzes.—To produce alloys of copper with tin, zinc, lead, etc., Mr. A. J. Rossi, the pioneer of the titanium industry (Titanium Alloy Manufacturing Company), proposes to alloy the copper not with pure tin, zinc or lead, but with alloys of these metals with titanium. The titanium has a purifying effect and enables sound castings to be made, since the formation of blow holes, due to gases, is avoided. To make, for instance, an alloy of titanium with tin, he mixes tin with tin oxide, titanic acid and aluminium shots together and heats them in an electric furnace. This causes the following two reactions:

$$3SnO_2 + Al_4 = 2\,(Al_2O_3) + 3Sn$$
$$3TiO_2 + Al_4 = 2\,(Al_2O_3) + 3Ti$$

A fusible slag such as broken glass or a mixture of glass with iron blast furnace slag is useful as a protection of the molten bath. Such a protection is necessary in the manufacture of the zinc-titanium alloy. In the same way alloys of titanium with lead or with manganese can be made. (935,863, Oct. 5, 1909.)

Alloys.

Substitutes for Platinum.—As a substitute for platinum for electrical contacts E. B. Craft and J. W. Harris (Western Electric Company) have patented an alloy having the following composition: Gold, 67½ per cent to 70 per cent; silver, 25 per cent; platinum, 5 per cent to 7½ per cent. A second patent refers to another alloy of the same composition as the one just described with the exception that 5 per cent to 7½ per cent of nickel are substituted for the platinum. Both alloys are claimed to have all of the characteristics peculiar to platinum, to be considerably cheaper and somewhat harder. (937,284 and 937,285, Oct. 19, 1909.)

Wood Pipe.

The question of securing satisfactory piping for the large quantities of water under pressure often required by mining operations or for hydroelectric power development in rugged portions of the West is one of considerable importance. Large-size cast-iron pipe is with difficulty transported and laid in inaccessible regions, and wrought-iron and steel pipe has often been resorted to.

The National Wood Pipe Company, of Portland, Ore., San Francisco, Cal., etc., is manufacturing pipe of redwood or fir staves which they recommend for this and similar classes of work. "Machine banded pipe" is made in sections up to 20 ft. in length, of diameters from 2 in. to 24 in., and for pressures up to 400-ft. head. The banding consists of heavily galvanized steel-wire, which after winding, is coated with hot asphaltum and tar. Cast-iron, wood or steel collars are used

to connect sections. This makes a satisfactory pipe for water works, mines, hydraulic dredges, electric conduits and steam-pipe covering.

"Continuous stave pipe" is made in larger sizes, from to in. to 12 ft. diameter, and from 100 ft. to 100 miles in one length, and is constructed to withstand pressures ranging from 20-ft. to 300-ft. head. It is, of course, built continuous, and in place, all staves, bands and other material being delivered to the pipe line in knock-down form. The ends of the staves are connected by a tongue which prevents butt-joint leakage and the pipe is banded with individual threaded round-steel rods, held in place by malleable or cast-steel shoes.

Among the advantages claimed by the manufacturers are that this pipe is not rusted or corroded by water, minerals, acids or fumes, does not taint fluids flowing through it, is not easily burst by freezing, requires less experience and labor to lay, is cheaper than iron or steel, and more durable than either thin steel or wrought-iron pipe.

High Vacuum Air Pumps.

Some years ago chemical works were satisfied with an average vacuum of about 2.75 in. of mercury absolute pressure for evaporating and similar purposes. It has now been realized that great advantages can be obtained by using the highest possible vacuum. Among these might be mentioned the following:

1. To greatly increase the efficiency of existing evaporating or distilling plants without any alterations to the apparatus.

2. To evaporate liquids at ordinary temperatures which otherwise could only be evaporated by means of hot steam.

3. To distill fluids which could not be evaporated in a low vacuum plant, because of the damage done at the higher temperature corresponding to the low vacuum.

4. To evaporate very quickly by means of a high vacuum such fluids which possess a high boiling point.

The above advantages can easily be accounted for when we remember that the higher the vacuum the lower is the equivalent

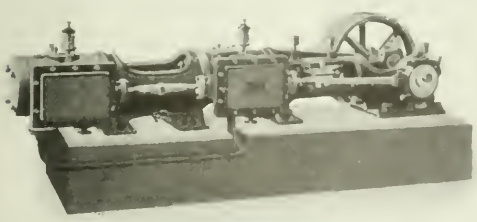


FIG. 1.—HIGH-VACUUM PUMP.

evaporating temperature—that is, the well-known curve giving the relation between pressure and evaporating temperature changes rapidly as the point of absolute vacuum is approached and we then get a more rapid decrease in evaporating temperature for a slight increase in vacuum than when working at lower vacua. The firm of Klein, Schanzlin & Becker, of Frankenthal, Pfalz, Germany, are manufacturing a line of dry vacuum pumps with an improved system for pressure equalization (Burckhardt & Weiss) which is designed to take advantage of these possibilities.

The slide valve has been adopted and with a view to obtaining the highest volumetric efficiency the valve is fitted with trick passage, which places both sides of the piston in communication at the end of the stroke and thus practically neutralizes the effects of clearance. The accompanying indicator cards (Figs. 2 and 3) show the effect of this device.

By thus equalizing the pressure at the end of the stroke, the full suction effect is obtained early, and, as shown here, about 93 per cent of the stroke is utilized for suction as compared with

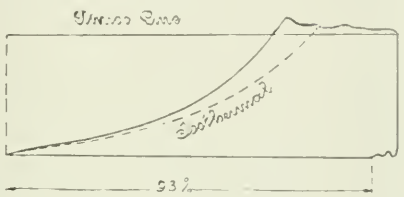


FIG. 2.—INDICATOR DIAGRAM WITH EQUALIZATION OF PRESSURE.

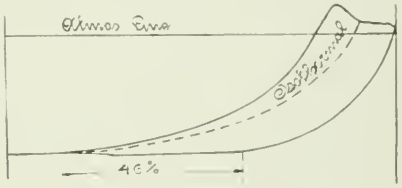


FIG. 3.—INDICATOR DIAGRAM WITHOUT EQUALIZATION OF PRESSURE.

46 per cent on the pump without equalization of pressure. This is particularly important when working with a high vacuum, for here, with the necessarily high ratios of compression, it is sometimes the case that an air pump without equalization gives no suction effect at all; in other words, the efficiency is zero.

For very high vacua, up to 0.02 in. of mercury absolute pressure, the manufacturers recommend the adoption of the two-stage air pump, in which each cylinder is of the same design and dimensions as the cylinder of the standard single-stage pump. The two-stage pump is arranged so that the second cylinder draws the air from the first cylinder, compresses it, and discharges at atmospheric pressure. No compression, therefore, takes place in the first cylinder, and by this design a very high vacuum is obtainable.

This pump is now being used with marked success in many of the more important incandescent lamp factories both here and abroad. Mr. J. W. Sittig, of Temple Court Building, New York City, is the American representative.

French Bauxite.

Red French bauxite contains about 60 per cent to 63 per cent of alumina, about 20 per cent of iron, while the silica contents are less than 2 per cent. This red bauxite is used principally in the production of alumina for the manufacture of the metal aluminium. In the refining process of this red bauxite the high percentage of iron is not objectionable, while a high percentage of silica content is almost fatal to economical manufacture.

Bauxite of this character seems to be only found in large quantities in the South of France in districts extending from the province of Var, near Toulon, in a westerly direction toward the foot of the Pyrenees. A number of years ago the various bauxite properties were controlled by a great many small and irresponsible companies, but 10 or 12 years ago most of the best of these properties were acquired by the Société Anonyme de l'Union des Bauxites de France. This company has supplied nearly all the imported bauxite which has been used up to date for the manufacture of aluminium in this country. While the present sole producer of aluminium in this country is believed to have a virtual control of the American bauxite deposits which are suitable for the production of aluminium, it will be gratifying to those interested to learn that there are still huge quantities of the French bauxite of the quality best adapted for this manufacture which may be purchased by those desiring to enter the aluminium business now that the basic patents have expired. The Continental-American Ore Company, of 33 Broad Street, Boston, Mass., have the American agency for this red French bauxite.

Titanium-Steel Rails.

In our March issue, page 128, we published an interesting article by Mr. Charles V. Slocum on the use of titanium in steel for rails, wheels, etc. Since, after all, the proof of the pie is in the eating, the adjoining comparative photographs of standard Bessemer and titanium-treated steel after simultaneous use under heavy traffic are decidedly interesting.

On Oct. 7, 1908, 24 rails were placed in service for comparative trial on Kesslers Curve, Cumberland Division, B. & O. Railroad. Seventeen of these were treated with titanium alloy, the other seven were plain standard Bessemer.

These rails were placed on both the high and low sides of this 9-deg. curve, which is in almost constant use under heavy

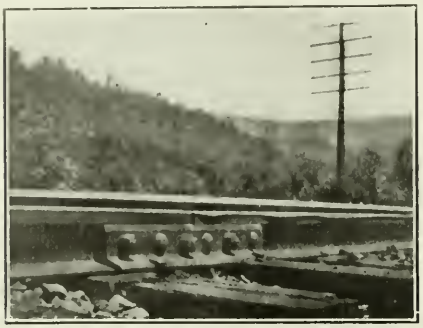


FIG. 1.—KESSLERS CURVE. LOWER LEFT-HAND RAIL TITANIUM-STEEL. LOWER RIGHT-HAND RAIL STANDARD BESSEMER.

traffic. Photographs were taken on July 8, 1909, exactly nine months from the date these rails were laid.

All of the 17 titanium rails were then in excellent condition. In Fig. 1 the lower right-hand rail is standard Bessemer steel, the lower left-hand rail titanium-treated steel. The difference is indeed very remarkable. In Fig. 2 the lower rail is of standard Bessemer steel.

At that time diagrams were also obtained directly from the rails by R. W. Hunt & Company, engineers, New York and Chicago, showing that the loss by wear from the Bessemer

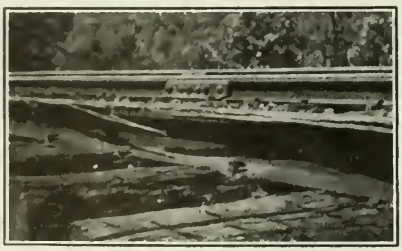


FIG. 2.—KESSLERS CURVE. LOWER RAIL STANDARD BESSEMER.

rails, in pounds per yard, was 294 per cent greater than from the titanium rails.

Concerning the later behavior of these rails, some interesting statements were made at the meeting of the Rail Committee of the American Railway Association in Niagara Falls on Monday, Oct. 4, by Mr. W. A. Thompson, engineer of maintenance of the B. & O. Railroad. He stated that all the titanium rails placed on the track on Kesslers Curve, Oct. 7, 1908, were still in service in good condition and had now shown more than 300 per cent increased durability over the standard Bessemer rails: these original titanium rails are now competing against the second set of standard Bessemer rails; the first set of the latter having been worn out and removed.

At the same meeting Dr. P. H. Dudley confirmed the remarkable showing of titanium-steel rails, as sketched above, on the basis of the results obtained on the New York Central lines.

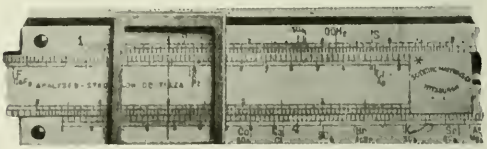
For the two photographs and for the above information we are indebted to Mr. Charles V. Slocum, the Pittsburgh representative of the Titanium Alloy Manufacturing Company, producers of ferro-titanium at their Niagara Falls works under the patents of Mr. A. J. Rossi, the indefatigable pioneer of the titanium industry. They also produce titanium-copper.

Chemists' Slide Rule.

The Scientific Materials Company, of 717 Forbes Street, Pittsburgh, Pa., has placed on the market a slide rule designed especially to reduce the time required for the calculation of chemical analyses to a few seconds, and at the same time to increase the accuracy of the results. The calculations for which it serves include multiplication, division, and the determination of various powers of numbers. The extraction of roots is also possible, but is a little more complicated.

The ordinary slide rule is now such a familiar and absolutely necessary device, used by engineers all the time, that there is no necessity of explaining its principle besides stating that it is a mechanical substitute for voluminous logarithmic tables and of sufficient accuracy for all practical calculations.

The chemists' slide rule is based on exactly the same principles as the old original slide rule, but it differs only in so far as it has certain marks especially useful in chemical calcula-



CHEMISTS' SLIDE RULE.

tions. The chemists' slide rule consists of a bar of mahogany having a tongue or slide moving in a groove along its center and a metal frame having a glass plate, which by means of a finely ruled line aids in making readings. Part of the chemists' slide rule is shown in the adjoining illustration.

As it is well known, the ordinary slide rule is particularly suitable for the calculation of proportions. And this is the reason why the chemical slide rule is so useful in any calculation of analyses. This involves the use of proportions and may be expressed by the equation $FP \div S =$ percentage, in which F is the factor, P is the amount of substance found, and S is the quantity taken. As the factors are constant numbers, they have a fixed place on the slide rule, and are indicated by a mark on the scale. This makes the use exceedingly simple. Certain elements are determined in different forms of combination and have consequently different factors. The marks corresponding to the factors are placed above the logarithmic divisions in order not to cause confusion.

In the case of elements or atomic groups, which are always determined in one and the same form of combination, for example, carbon as CO_2, hydrogen as H_2O, there is entered in large letters along with the factor the symbol of the element or atomic group. In the case of elements which may be determined in different forms of combination the symbols of these different forms are expressed by smaller letters. The fact that these important factors do appear distributed both on the rule and on the slide promotes the clearness and facilitates the readings.

To those who are familiar with the slide rule, its eminent

usefulness for chemical calculations will be evident. There is, of course, required a certain familiarity with its use, but, as any engineer can testify, this familiarity is very quickly acquired by constant use. There seems to be no reason why the slide rule should not become as indispensable for the chemist as it has been in the past for the mechanical and electrical engineer.

Notes

Conical Mills.—We have received an interesting little model of the conical ball and pebble mill manufactured by the Hardinge Conical Mill Company, 39 Wall Street, New York City. This mill was described and illustrated in our January issue of this year, page 47. The model is 3 in. diameter, made of glass and mounted on an aluminium base. It is partly filled with sand, beads, and pebbles, of various sizes, and the transparent construction shows very neatly the peculiar sorting process by which the different pebbles arrange themselves according to their size. No matter what the initial arrangement may be, a dozen turns or so are sufficient to collect the fine ground product at the discharge end of the cone.

Nichrome Resistance Wire.—In the field for resistance wires for electric heating apparatus, many efforts have been made to find some alloy that has the eminently desirable features of platinum and yet can be produced at a lower cost. The Driver-Harris Wire Company, of Harrison, N. J., are now manufacturing a nickel-chromium alloy under the trade name "Nichrome" which promises to solves this perplexing problem. This wire is exceedingly satisfactory for use in laboratory electric furnaces, pyrometers and thermo-couples, and electric heating specialties in general. The resistance per mil foot is 575 ohms and the temperature coefficient 0.00024 per degree Fahr. We have seen a sample of this wire which had been continuously run in air at 1500° Fahr. for three months, and then left exposed to the fumes of a chemical laboratory for some months longer. No deterioration was evident and the wire appeared to be as good as new. In a shorter test a temperature of 2500° Fahr. in the open air was obtained without any trace of deterioration.

Wrought-Steel Floor Plates.—Some interesting comparisons of wrought-steel and cast-iron floor plates for floors and stairways in engine and boiler-rooms, factories, power plants, etc., are given in a recent folder issued by the Keystone Steel Co., of Warren, Pa. Wrought-steel plates are useful for all inside and outside work where, besides handsome appearance, a roughened surface is desired to prevent accidents from slipping, to resist wear and to insure a safe and light construction at a low cost. "Diamond," "ribbed" and "checkered" patterns are gotten out under the trade name "Kesco," and are made in various sizes up to 72 in. x 120 in. and from ⅛ in. to ¾ in. thickness. The advantages claimed are: 50 per cent stronger than cast iron, 30 per cent cheaper than cast iron, and freedom from accidental breakage. These wrought-steel floor plates are made from finest open-hearth boiler steel.

Steel Mill Machinery.—Among the neatest of new catalogs we have received is one by MacKintosh, Hemphill & Company, Fort Pitt Foundry, Pittsburgh, Pa. There are introductory notes on the history and the present manufacturing facilities of the company, with a view of the works and views of the machine shop. The rest of the book is divided into sections on: 1. Rolling mills for blooms, plates, rails, sheets, etc. 2. Engines, simple, reversing, blowing and air compressors. 3. Miscellaneous machinery for iron and steel works, including shears, saws, cambering machines, hydraulic presses, accumulators, riveters, punches, flywheels, etc. There are some eighty-seven pages of admirably executed half-tone cuts giving elevations, plans, and sections, and the book as a whole fittingly represents one of the old-time and yet modern and progressive foundries of the Pittsburgh district.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Electric Furnaces (Continued).

640,283, Jan. 2, 1900, Francis E. Hatch, of Norway, Mich.

Resistance type. The furnace is a short horizontal cylinder of fire clay, closed at its ends and mounted to rotate on a central shaft projecting from one end. The heating of the charge is effected by a series of 96 carbon resistors, secured to the inner face of the cylinder, there being six longitudinal rows of 16 carbons each. The resistors of each row are supplied with current and thereby heated as they descend, with the rotating cylinder, beneath the charge. The current is maintained on them while they pass beneath and until they rise from and again leave the charge at its opposite side. The electric current is fed successively to the six rows by a six-part commutator. The furnace is especially designed to smelt a mixture of iron ore, a reducing agent, such as carbon, and a flux of lime.

The cylinder may be revolved continuously or intermittently, the ore tumbling over and covering the lowermost resistors.

641,552, Jan. 16, 1900, Marcus Ruthenburg, of Philadelphia, Pa.

Resistance type. A body of fine ore or concentrates, e.g., magnetite, is agglomerated into porous lumps by heating a body of it until the contiguous corners of the particles fuse and adhere. The furnace is a graphite crucible serving as cathode and receiving a depending carbon rod anode. To agglomerate magnetite comminuted to pass a screen of 40 meshes per inch, the current density is 1000 amp per square inch of anode surface, at a voltage of 10 to 20, the current being maintained for five minutes.

641,976, Jan. 23, 1900, Robert H. Laird, of Pittsburgh, Pa.

Arc type. A stack furnace for smelting gold and silver ores. The furnace is surrounded by a water jacket and has a bell- and hopper-charging mechanism at the top. A series of downwardly inclined rod electrodes pass through the side walls, being arranged in two helical opposite rows. A series of pipes for air or steam enter the top of the furnace and a flue for gaseous products leads from the bottom to a "gas tank." This tank has an exhaust fan and a water-sealed outlet. The tank may be replaced by a zigzag pipe surrounded by a cooling medium and connected through an exhaust fan to a gas-storage chamber. Three delivery pipes, with cocks, lead from the bottom of the furnace at different heights. A pipe serves to introduce water for cleaning the furnace. In operation, the air or steam injected at the top of the furnace causes a down-draught and increased combustion, expelling the gases into the storage chamber

643,254, Feb. 13, 1900, Albert Johan Peterson, of Notre Dame de Briancon, France, assignor to the Société des Carbures Métalliques, of Paris, France.

Resistance type. Especially designed for the manufacture of calcium carbide. The furnace comprises an upper fixed portion receiving the charge mixture and a lower movable portion, containing the resistor—a rectangular layer of molten carbide beneath the ends of which are carbon contact plates of opposite polarity, carried on iron plates or bars. Heating flues extend through the upper part of the furnace, receiving the waste gases from the smelting zone, burned by air introduced through suitable ports. The lower movable part of the furnace has air spaces and channels for cooling the electrodes and hearth. The furnace is operated continuously, the raw materials being charged in above and carbide discharging through a tap hole. In starting, current may be initially passed between the contact plates through a layer of carbide in small pieces, or through a core of carbon, which disappears during the smelting.

NEW BOOKS.

Steinmetz, Charles P. Theoretical Elements of Electrical Engineering. 455 pages. Price, $4 net. New York: McGraw-Hill Book Company.

Steinmetz, Charles P. Radiation, Light and Illumination. 305 pages. Price, $3 net. New York: McGraw-Hill Book Company.

McAllister, Addams Stratton. Alternating-Current Motors. Third edition, revised and enlarged. 334 pages. Price, $3 net. New York. McGraw Hill Book Company.

Franlin, W. Sudlards, and Esty W. Dynamos and Motors. A text book for colleges and technical schools. Direct current and alternating-current machines. 497 pages. Price, $1.40 net. New York: Macmillan Company.

Lea, F. C. Hydraulics for Engineers and Engineering Students. 548 pages. Price, $1.50 net. New York: Longmans, Green & Company.

Unwin, W. Cawthorne. The Elements of Machine Design. Pt. 1. General principles; strength of materials; journals and shafting; couplings; pedestals; transmission of power by gearing, belting, ropes and chains. New edition, revised and enlarged. 545 pages. Price, $2.50. New York: Longmans, Green & Company.

Trautwine, J. Cresson. Trautwine's Civil Engineer's Pocket-Book. Nineteenth edition, revised and enlarged. By J. C. Trautwine, Jr., and J. C. Trautwine, 3d. 1300 pages Price. $5 net New York: John Wiley & Sons.

BOOK REVIEWS.

Abhandlungen der Deutschen Bunsen-Gesellschaft. Nr. 1. Uber die Erhaltung der Masse bei chemischen Umsetzungen. By H. Landolt. 47 pages. Price, 1.80 marks (retail price in New York, 60 cents); price for the members of the Bunsen Society, 1.00 marks. Halle a. S.: Wilhelm Knapp.

The German Bunsen Society, at its convention last year in Vienna, decided to venture upon a new form of publication, besides its excellent and well-known semimonthly journal, the *Zeitschrift fur Elektrochemie*. The scheme of the new form of publication is to issue at irregular intervals pamphlets of a larger size than would be suitable for publication in article form in a periodical journal.

These pamphlets are to represent the results of extended investigations which have led to definite results. They are to be, therefore, in the form of monographs. In the same may be repeated what has been published before, but the chief object is to give a concise definite statement of the latest results obtained. The society intends to be very careful in accepting monographs for this serial. Besides the editor, Prof. F. Abegg, one of the members of a special committee (consisting of Profs. Nernst, LeBlanc, Foerster, and Elbs) must vouch for the scientific value of the monograph.

The scheme is excellent, and the first number, which has just been issued, shows clearly what is intended. In the first number a summary is given of the extended researches carried out by Prof. H. Landolt during the past 18 years on the question whether the fundamental principle of the conservation of mass in chemical reactions is absolutely correct. The investigations were made with greatest care, and from the summary of the results it appears that the experimental discrepancies from the above principle were one-half in one direction and the other half in the other direction and practically below the error of measurements. The principle of the conservation of mass may, therefore, be considered as having been established with the greatest accuracy now obtainable.

In spite of the fact that this result is of anything but a revolutionary character, the study of Landolt's long-extended researches will be found very interesting.

We wish the Bunsen Society godspeed in this new enterprise and trust that the following monographs will be of equal value as the first one.

* * *

Text-Book of Physics. Edited by A. Wilmer Duff, D.Sc. Second edition, revised. 698 pages, 325 illustrations. Price, $2.75 net. Philadelphia: Blakiston's Sons & Company.

This excellent manual of physics is arranged in seven sections, which have been prepared by six different writers who are professors of physics. The sections and writers are: "Mechanics and the Properties of Matter," Dr. A. W. Duff, Worcester Polytechnic Institute; "Heat," Dr. K. G. Guthe, University of Michigan; "Wave Motion" and "Light," E. Percival Lewis, University of California; "Electricity and Magnetism," Dr. Arthur W. Goodspeed, University of Pennsylvania; "Electromagnetic Induction," Dr. A. P. Carmen, University of Illinois; "Conduction of Electricity Through Gases and Radio-activity," Dr. R. K. McClung, Mount Allison University.

A review of the first edition of this book was given on page 98 of our February issue. For the second edition the section relating to wave motion has been completely rewritten, and certain minor changes have been introduced in other sections. A change has been made in the typographical arrangement so that the fundamental facts are presented in large print and the features of secondary importance are discussed in fine print. This arrangement renders the book better adapted for class work at the various universities where it is used as a text. The very short time elapsed since the appearance of the first edition is a practical proof of the usefulness of the work.

* * *

The Rise and Progress of the British Explosive Industry. Published under the auspices of the Seventh International Congress of Applied Chemistry by its Explosives Section. 418 pages, profusely illustrated. Price, $5.25 net. New York: Macmillan Company.

At a preliminary meeting of the Committee of the Explosives Section of the Seventh International Congress of Applied Chemistry, held this summer in London, it was proposed by Mr. Oscar Guttmann, and carried unanimously, that a history of the rise and progress of the explosive industry in the British Isles should be compiled. A publication subcommittee was formed consisting of Captain T. C. Tulloch, Major Cooper-Key, Mr. Oscar Guttmann, and Dr. W. R. Hodginson. Mr. E. A. Bragley Hodgetts was appointed editor.

The outcome of this committee's work is a most handsome, beautifully illustrated and intensely interesting volume, embodying a vast amount of information in most convenient form. Mr. T. G. Tulloch is right to say in the preface that posterity is under obligation to Mr. Guttmann, to whom the book owes its inception, and to his coworkers, because in years to come this book will be looked upon as a work of reference connecting the past with the future, for it is the only work of the kind containing so complete a history of the manufacture of explosives, not in Great Britain alone, as might be inferred from the title, but in general.

The bulk of the book contains historical sketches on the history of gunpowder (E. A. B. Hodgetts), researches on gunpowder and nitrocellulose (G. W. McDonald), nitro-glycerine and permitted explosives (H. de Mosenthal), percussion caps (E. W. Hulme), Bickford's safety fuse (G. J. Smith), military fireworks (J. R. J. Jocelyn), pleasure fireworks (P. Pain), legislature (E. A. B. Hodgetts), followed by a full bibliography, a most excellent chronology of the explosive industry from 1242 to 1700, and a list of gunpowder makers up to 1800. The second part of the volume contains concise descriptions of existing government and private explosive factories in Great Britain.

Electrochemical and Metallurgical Industry

VOL. VII. NEW YORK, DECEMBER, 1909 No. 12

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York

PITTSBURGH OFFICE, 413 Lewis Block.
EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH.D.....*President*
E. F. ROEBER, PH.D.....*Editor and Secretary*
C. E. WHITTLESEY.....*Treasurer*

Yearly subscription price for United States, Mexico and United States dependencies, $2.00; for all other countries, $2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, DECEMBER, 1909

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The Proposed New Chemists' Club Building.

The Chemists' Club, of New York, has become the professional home of all chemists of this country. It has acted as the host of all the different chemical societies. It has created a true chemical democracy. The spirit which it has created is reflected in the way in which progress is being made with the project of erecting a fine large new home for the Club. At the last smoker (a Harvard night, at which Prof. Theodore W. Richards was elected an honorary member of the Club) it was announced that $210,000 had so far been subscribed for the building. To bring the project to a successful end must be the ambition of every American chemist for the Chemists' Club does not stand for New York alone; it represents the united democracy of American chemists.

Standardization of Dry Cells.

The dry-cell industry in this country has now an annual output of some 40,000,000 cells and is still continually growing. But the general lack of exact knowledge about the dry cell is appalling, while the usual methods of rating dry cells reminds one at best of kindergarten methods for making electricity easy. It is certainly high time that a logical method for rating dry cells should be adopted. As a result of the two papers by Mr. Loveridge and by Professor Burgess and Mr. Hambuechen, the American Electrochemical Society has stepped in here by appointing a committee to standardize methods for rating and testing dry cells. This is an important undertaking. It is evident that the present usual method of rating cells by dimensions or by the short-circuit current must be replaced by a method of rating by energy output. But such a method requires an exact definition of the conditions under which the cell is to be tested. It would be strictly logical to change these conditions of testing according to the purpose for which the cell is to be used. However, this would result in several different ratings for the same cell, according to the different purposes for which it can be used, and thus could easily cause confusion. It might be preferable to compromise on one all-around test for practical reasons. The work of the committee will not be exactly easy, but it must be done.

An Electrochemical Load for Central Stations.

More than once have we referred in these columns to the possibilities of using the power of central stations at times of low load for electrochemical and electrometallurgical purposes. There is something mutually attractive in such a scheme for central-station men on one hand and electrochemists on the other hand. The latter want cheaper power and the former a better load factor. With respect to electrolytic processes the objection has often been raised that it would not do to run them intermittently or even interruptedly, and that for best operation absolute uniformity of the load is necessary. But Mr. Spalding's paper, published in this issue (page 536), shows that

a sound compromise is possible and practical. His account of what is actual practice in a successful electrolytic copper refinery, in combining electrical energy generated from the waste heat of furnaces with energy brought from a power company, should prove suggestive reading; and it should be kept in mind that in this case the refinery buys part of the needed energy from the power company, although the price charged by the latter can hardly be called liberal.

Design of Electric Furnace Electrodes.

The rapid progress of the use of electric furnaces in commercial operation has necessarily resulted in great advances in design. This fact is well illustrated by the numerous articles relating to electrode design published during the past year in our columns, especially the articles of Mr. Hansen and Mr. Hering. An account of a discussion of the problem of electrode losses in several papers at the recent meeting of the American Electrochemical Society will be found in the convention report in this issue. In view of the mass of literature now in existence on this special subject, it seems worth while to state in the simplest non-mathematical language and as briefly as possible the fundamental principles. Let us assume that we have an electrode of given dimensions and keep its one end at a certain high temperature (furnace temperature) and keep the other end cool (for instance, by a water jacket). If no electric current passes through the electrode, we have simple heat conduction from the hot end to the cold end due to temperature difference. When we begin to pass a current through the electrode we have a superposition of two phenomena: the simple heat conduction as before, due to the temperature difference at both ends, and the generation of heat from electrical energy within the electrode. The latter, the total Joulean heat generated within the electrode, tends to flow off impartially to both ends, one-half to one side and one-half to the other side. Hence, the heat loss from the cold end of the electrode into the water jacket is not only the heat conducted away due to the temperature difference at the two ends, but is increased by one-half the Joulean heat. This sum is termed the "electrode loss." At the hot end the heat which flows into the electrode from the furnace on account of the temperature difference between the two ends, is diminished by half the Joulean heat loss. If we increase the current steadily (always maintaining the temperatures constant at the two ends), the Joulean heat loss increases; and when it has grown to such a value that half the Joulean heat just equals the heat conduction loss due to temperature difference, then there will be temperature equilibrium at the hot electrode end. The two heat quantities—one due to temperature difference at the two ends and the other due to Joulean heat—just balance each other. No heat will flow through the hot electrode end in either direction. If we increase the current still further, the half of the Joulean heat flowing out from the hot end of the electrode into the furnace will actually overbalance the heat which would flow in the opposite direction due to the temperature difference between the two ends. In this case the temperature will be a maximum at some point within the electrode and from this point the temperature will decrease to both sides. For practical operation it seems generally advisable to make the conditions so that no heat flows in either direction through the hot electrode end. In this case the simple heat conduction, due to the temperature difference at both ends, equals one-half the Joulean heat, and the "electrode loss" (the heat given off to the water jacket) equals just the total Joulean heat.

* * *

For the sake of simplicity we have so far assumed that the temperatures at the two ends are maintained constant while the current is gradually increased in an electrode of given dimensions. In practice the problem is different, because the furnace temperature depends on the current. What is given are the current and the two temperatures at the two ends. What we want to find are the dimensions of the electrode, its length and cross-section. We want to select these so that half the Joulean heat equals the heat loss due to temperature difference between the ends. Now, it is evident that the Joulean heat loss is greater the longer the electrode and the less its cross-section; it increases with increasing ratio of length to cross-section. On the other hand, the heat conducted from the hot end to the cold on account of temperature difference between the two ends is smaller, the longer the electrode and the less its cross-section; it decreases with the increasing ratio of length to cross-section. The total electrode loss depends on the ratio of length to cross-section, and the preferable condition, in which the heat loss due to temperature difference equals half the Joulean heat, is fulfilled if the ratio of length to cross-section of the electrode has a certain value. This value depends on the electrode material, the current, and the temperatures at the two ends. As analysis shows, this value is inversely proportional to the current. Therefore, instead of saying that for the best conditions of operation the ratio of length to cross-section is fixed by current, electrode material, and the two temperatures, we can just as well say that the product of length of electrode and of current density in the electrode is fixed by the electrode material and the temperatures at the two ends.

* * *

Current density plays, however, another important part in furnace operation. Mr. Hansen states that as a result of his experience he has found that carbon electrodes cannot be run with a current density above a certain value nor graphite electrodes with a current density above another certain value, without corroding badly the end walls of the furnace. This statement can be slightly generalized by stating that the current density should not be so high that undesired decomposition of the walls or of the furnace charge near the electrode end are produced. We know of at least two cases in practice in which by forcing the current density too high, quite considerable losses resulted from evaporation from the charge near the electrode end. Clearly this is a matter of temperature, and the temperature depends on the number of watts per cubic centimeter, which are determined by the current density. The current density, therefore, plays an important rôle in this respect, but this cannot be easily formulated in general rules, since the permissible temperature depends on the conditions of every special case, not only on the electrode material, but on the nature of the material of the walls and of the charge under treatment.

Electric Smelting of Iron Ore.

There can be no doubt that in not too far a future there will be a number of commercial electric furnaces operating for the reduction of iron ore in specially favored localities—favored by

cheap electric power and a good market, but unfavorable to blast-furnace operation. The only doubtful matter is the details of the design of the electric furnace for iron-ore reduction. As our readers know, the problem has been taken up on a practical scale, both in California and Sweden. In both localities the work is progressing and the outlook is stated to be promising. But finality has not been reached by any means. There seems to have been a hitch in carrying through the project of starting a really commercial smelting plant using the Swedish electric shaft furnace. Nevertheless, progress has been made toward commercial operation, as will be seen from the following report which has just reached us and which may be considered as authoritative: "In order to carry out a fully impartial and exhaustive test of the electric shaft furnace for pig-iron production constructed by the A. B. Elektrometall in Sweden, the Jernkontoret—a representative organization of all the Swedish iron and steel works—will take over the plant to be erected in Trollhattan. One furnace of 2500 hp capacity will shortly be built for this purpose and, in case of success, the Jernkontoret will acquire the Swedish patent rights of the inventors, paying a royalty of 1.25 kr (33.5 cents) per metric ton of iron produced by its members in the furnace. A sum of 250,000 kr. ($67,000) has been voted for the experiments which will extend over a period of two years." Qui vivra verra.

* * *

In this connection the American Electrochemical Society paper of Mr. Edward R. Taylor, which is published elsewhere in this issue, is interesting. The design of his electric iron-ore reduction furnace has many points of similarity with his carbon-bisulphide furnace, which is commercially successful on a large scale. But the chief point of interest is the scheme of charging the ore and the fuel separately into the furnace. Since doubts have been raised in the discussion of Mr. Taylor's paper as to the advisability or practicability of such a scheme, it seems worth while to discuss it somewhat more in detail, as it has to do with one of the most fundamental points of the whole problem. There can be no doubt that under the special conditions, under which electric iron smelting can be commercially successful, it is important to utilize to the utmost within the furnace itself the energy value of the coke used as reducing agent. The ordinary blast furnace is a large gas producer on account of the carbon monoxide contained in the gas given off. This gas is utilized outside of the furnace, most efficiently in gas engines to produce electric power. With electric iron smelting, for which the availability of cheap electric power is presupposed, such a procedure is hardly attractive. The object must be to transform, if possible, all the carbon into carbon dioxide within the furnace itself. The question is, therefore: why is this impossible in the blast furnace and under what conditions would it be possible in the electric furnace?

* * *

The essential point is that the combustion of carbon to CO_2, either in the electric furnace or in the blast furnace, cannot be complete, as long as the ore and carbon are charged together. In this case the amount of CO_2 formed (in comparison with C and CO, with which it is in contact) is limited, since it cannot be more than the proportion corresponding to the equilibrium between the different substances which are in contact with each other. If we assume, for the sake of argument, that it was possible to change all C to CO, in some way, then the reverse reaction would immediately take place, by which the CO_2 would be reduced to CO by the elementary carbon with which it is in contact. For this reason the blast furnace and any furnace in which the charge is introduced mixed together, is necessarily a gas producer yielding a combustible gas. It is entirely different—at least in theory—if the iron ore and the carbon are introduced separately into the furnace and are mixed together only in or near the smelting zone. In this case a mixture of carbon monoxide and carbon dioxide will be formed, and when this gas mixture is made to expand through the charge of iron ore (which is not mixed with carbon), there will be further reduction of iron oxide by the carbon monoxide which is thereby changed to carbon dioxide. Even so, when the gas mixture has risen to a certain height, it will be so dilute that no further reduction takes place. But then it is still possible to blow at this point air from the outside into the gas mixture and burn the carbon monoxide within the furnace itself so as to preheat the charge. In this way and only under the condition of the absence of elementary carbon at this point is it possible to utilize the whole energy value of the carbon within the furnace itself.

* * *

This scheme, in its fundamental principle, is not new. It was the underlying idea of Mr. Héroult's iron-ore reduction furnace, described in our Volume IV, page 152. He recognized clearly that the higher the point where the air is finally blown in for the combustion of the carbon monoxide, the greater will be the utilization of the reducing power of the carbon monoxide, although such reducing power is a diminishing quantity. The lower the point of injection of air, the greater is the heat developed and the less the reduction of ore. But the method of charging the carbon and ore separately into the furnace is different with Dr. Héroult and Mr. Taylor. In Dr. Héroult's original scheme a hollow central electrode was used through which the carbon was fed down. Yet electrodes offer enough troubles, anyway, leaving aside specially constructed hollow electrodes. Mr. Taylor's method seems far more feasible and practical. When in the historic trials at Sault Ste. Marie with the Heroult shaft furnace, under Dr. Haanel's direction, a single experiment was made blowing air into the charge near the top of the shaft, trouble was experienced due to the charge sticking on account of the heat developed. Whether any similar difficulty would be experienced with Mr. Taylor's furnace is an open question, since the design is quite different.

* * *

Another criticism made in the discussion of Mr. Taylor's paper by Mr. Hansen brings out clearly the great practical advantage of intimately mixing together the different substances which are to act on each other. But the conditions of Mr. Hansen's ferrosilicon furnace appear to be different from those in the Taylor furnace, where provision is made (by means of screws) to bring about an intimate mixture of ore and carbon near the smelting zone. How far this is possible can hardly be guessed. How the screws and other details of the design would work can also be found out by experience only. It is a pity that Mr. Taylor does not seem to have made any actual trials of his furnace on a large scale. But, in any case, his furnace construction is interesting in so many ways that it should be tried. After all, the proof of a furnace is in the running.

Nichols Medal.

At the meeting of the New York Section of the American Chemical Society, held in the Chemists' Club on Nov. 5, the Nichols medal was awarded to Dr. Leo H. Baekeland for his papers on "The synthesis, constitution and industrial application of bakelite" and "soluble and fusible resinous condensation products of formaldehyde and phenol." We heartily join Dr. Baekeland's many friends in extending to him our sincere congratulations on the honor which has been conferred on him and which is so well deserved.

Chemists' Club Building.

The Percolator is the title of a new monthly bulletin of the Chemists' Club. The issue of Nov. 15 contains some interesting information concerning the proposed new Chemists' Club Building.

The incorporation of the Chemists Building Company is now complete. At a meeting held on Nov. 12 the following directors were chosen. Morris Loeb, president; Charles F. Chandler, vice president. Albert Plaut, treasurer; W. H. Nichols, Jr., secretary; Leo H. Baekeland.

The architects are busy with the plans of the building, and it is hoped that estimates can be obtained shortly. Subscriptions now amount to $165,550, but the finance committee are still lacking about $30,000 before the directors will be warranted in declaring the plan operative, and it is the duty of all those interested in the project to lighten the arduous labors of this committee.

While the Chemists' Club will profit largely by the erection of this building, the fact cannot be emphasized too strongly that all the chemists of the United States will be benefited to an equal degree, not merely those residing in New York. Non-residents will find it a very suitable stopping place during their occasional visits to the city, and particularly convenient by reason of the library and other professional conveniences which this building will contain.

The Chemists' Club Building Company is independent of any management from the Chemists' Club. Subscribers to the stock will have a permanent equity in New York real estate, and while their dividends are limited to 3 per cent. so long as the Chemists' Club is in prosperous existence they are to be shareholders in a well-constructed office building, in the best possible business location, should the club, for any reason, fail to fulfill its present prospects.

This is a very different plan from the ordinary scheme, whereby a club erects its own building on a very slender margin and obtains additional funds by selling bonds to its own membership which can only be liquidated through expensive foreclosure proceedings. Anybody intending to subscribe should communicate with the chairman of the subscription committee, Mr. Maximilian Toch, 320 Fifth Avenue, New York City.

American Institute of Chemical Engineers.

The second annual meeting of the American Institute of Chemical Engineers will be held in Philadelphia from Dec. 8 to 11. The headquarters will be the Hotel Walton, where the first meeting will be held on Wednesday, Dec. 8, at 10 a. m. After a business session, the following two papers will be presented and discussed:

"Natural-Draft Gas Producers and Gas Furnaces," by Ernest Schmatolla. (Discussion by O. K. Zwingenberger and G. E. Barton.)

"The Commercial Extraction of Grease and Oils," by William M. Booth. (Discussion by Frederick Dannerth, Louis Olney and Samuel P. Sadtler.)

For the afternoon various visits have been arranged, either to the chemical, engineering and physical laboratories of the University of Pennsylvania, or to the Commercial Museum of Philadelphia, or to the works of Harrison Brothers & Company at Gray's Ferry Road.

In the evening at 7:30 the address of the retiring president, Dr. S. P. Sadtler, will be delivered, and will be followed by an address of Prof. Charles E. Munroe on the chemical industries of America.

On Thursday at 9:30 a. m. the members of the Institute and their guests will assemble at Race Street Wharf, on the Delaware, and be conveyed by the city boat *S. H. Ashbridge* to the Torresdale filtration plant; returning stop at Tacony to visit the wool degreasing plant of Erben, Harding & Company. Luncheon will be taken at the works of the Welsbach Light Company as the guests of the company. The party will then be conducted through the works of the Welsbach Light Company. In the afternoon the party will return by boat to Kaighn's Point, and a visit will be paid to the by-product coke oven plant of the Camden Coke Company.

In the evening a subscription dinner will be held at the Hotel Walton (price, $3).

On Friday morning the new officers of the society will be installed and a business meeting will be held. This will be followed by the reading and discussion of papers:

"Multiple-Effect Distillation," by F. J. Wood.

"The Advantages of the Multiple-Effect Distillation of Glycerine and Other Products," by A. C. Langmuir. (Discussion by S. S. Sadtler and Charles L. Reese.)

"Reclaiming of Waste India Rubber," by S. P. Sharples. (Discussion by William M. Grosvenor.)

In the afternoon an excursion will be made to Trenton, where the potteries, the Hamilton Rubber Company and the linoleum works will be visited.

In a meeting in the evening the following papers will be read and discussed:

"Materials for Textile Chemical Machines," by Frederick Dannerth. (Discussion by Louis A. Olney and J. M. Matthews.)

"Electric Smelting of Iron Ore," by E. R. Taylor.

"Chemical Composition of Illinois Coal," by A. Bement.

"Heat Efficiency of Smokeless Combustion and Heat Absorbing Capacity of Boilers," by A. Bement.

"Hydrogen Peroxide Solutions," by L. W. Andrews.

On Saturday, Dec. 11, an excursion will be made to the cement plants at Allentown, Pa.

Dr. Samuel P. Sadtler is the president of the Institute and Dr. John C. Olsen, Polytechnic Institute, Brooklyn, N. Y., is the secretary.

The Iron and Steel Market.

Actual new buying of finished steel products has been relatively light in the past month, partly because buyers are well covered, but largely also because the mills are pursuing a very conservative course and are avoiding sales far into the future unless the buyer absolutely requires the protection. Specifying on old contracts has been heavy all along the line, although the volume has decreased somewhat on account of contracts expiring Dec. 31 being already so well specified against.

The market does not present altogether as enthusiastic a tone as it did two months ago, but the position seems to be eminently satisfactory to producers, as the chief fear they have expressed has been of a runaway market.

Production records are being broken right along at individual plants and in individual trains of rolls, and the marvel is that in many cases the equipment has not been changed since previous records were made, generally in 1907.

The rate of pig iron production in November for the country at large passed 31,000,000 tons a year, compared with the maximum rate attained in 1907, 28,000,000 tons. The merchant furnaces have made but a very slight gain over their previous record, so that substantially the whole gain has been by the steel-works furnaces, indicating a large percentage increase. Scrap.

however, has been unprecedentedly scarce, commanding substantially as good prices as pig iron, and the make of open-hearth steel has probably not increased altogether as much as the make of basic pig iron.

Heavy melting steel delivered in the Pittsburgh district and in eastern Pennsylvania has been maintaining a level of $18 or higher, which is a high price compared with finished steel prices, while it is far above the cost of making pig iron to interests possessed of their own ore. In consequence the duplex process is being more and more considered, and within a few years perhaps the majority of the large independent steel interests will be found using it, while it is understood that the matter is being canvassed even as regards the Gary plant of the United States Steel Corporation. The general proposition is reduced to round figures thus: If scrap costs $18 on a half-pig and half-scrap charge, and pig iron can be produced at $14, from owned raw materials, and it costs $2 to blow the metal, then 2 tons of steel can be produced from material costing $16 a ton, instead of 1 ton from material costing $14 for half a ton and $18 for the other half, so that output is doubled without an increase in the cost per ton. The figures used, of course, are only conventional.

Lake Superior Ores.

On account of several spells of particularly bad weather, the accident to the Poe Lock at the American Soo and some minor accidents, the Lake Superior ore trade will probably be disappointed in its expectation of breaking the 1907 record for a season's movement, that standing at a trifle over 42,000,000 tons. An announcement of Lake Superior ore prices for the season of 1910 is likely to be made in the first fortnight of December. Several propositions are understood to have been under consideration, one a straight advance of 50 cents a ton, which would balance the reduction made for the season of 1908; another an advance of 50 cents on non-Bessemer ores and an advance of 75 cents on Bessemer ores, and another a reduction in the base guarantee of iron content from 55 per cent to 52½ per cent on Bessemer ores and from 51½ per cent to 50 per cent on non-Bessemer ores. The suggestions are tentative, and in case the base guarantee were lowered, the advance in prices per ton would not be as large as otherwise.

Coke.

The deadlock in Connellsville furnace coke for 1910 continues. About half the tonnage usually subject to contract for annual or semiannual periods was closed some time ago, chiefly in September, the price being run up to $2.90 per net ton at ovens. Contracts for the present half year had been made last May at $1.60 to $1.70, so that the advance was quite spectacular. There remains furnace consumption yet to be covered amounting to about 200,000 tons of coke per month, and it is possible that the buyers may wait until after the turn of the year before contracting, possibly buying prompt coke for a time as they evidently feel that developments are likely to be in their favor. Production in the Connellsville and lower Connellsville region has been running since the middle of October at a trifle above 450,000 tons weekly, the best weekly output attained in 1907 having just fallen short of 430,000 tons. There has been an increase of about 6000 in the number of ovens in two years, from a trifle over 33,000 to a trifle over 39,000. Some of the ovens are in connection with worked-out coal seams, as was also the case two years ago, the proportion actually available having undergone no important change. It is believed that with an adequate labor supply the region can work up to a weekly output in excess of 500,000 tons, which should be ample to cover prospective requirements for next year. The labor supply has been improving in numbers and efficiency, and a further improvement is expected after Jan. 1, as a general wage advance is in prospect for that date.

Pig Iron.

On the whole, the pig-iron markets have presented a strong tone, but have scored no important advances, and at some points weakness has appeared. Southern iron, which had been firm at $15, Birmingham, became available in October at $14.50, if for prompt shipment, while a valley furnace did some cutting in foundry iron. One or two lots of basic iron appeared in the East at cut prices. The advance in pig iron seems to have been arrested, but the month's developments are rather characteristic of a normal trading market than indicative of any declining tendency. Prices are quotable at valley furnaces (90 cents higher delivered, Pittsburgh), as follows: Bessemer, $19 to $19.10; basic, $17.25 to $17.50; No. 2 foundry, $17.25 to $17.50; gray forge, $16.25 to $16.50; malleable, $17.50 to $17.75; the range in prices representing chiefly difference in delivery, next year's deliveries being uniformly higher than prompt delivery.

Steel.

The Carnegie Steel Company has put its No. 2 mill at the Edgar Thomson steel works on billets. This is the original rail mill, and years ago it was regularly operated as an interchangeable mill, operating alternately on rails and billets, but for some time past it has not made billets. Part of the output goes to the No. 3 mill, the new light rail mill, electrically driven. The Nos. 1 and 3 mills are making 6000 tons to 8000 tons of rails a week, being gaited. The attached blast furnaces and converters are running full, surplus ingots and billets going to allied plants. Monday, Nov. 15, the company started its Bessemer converters at Homestead, which have been idle since 1907, the steel going chiefly to the structural mills. The long idleness of this Bessemer department, and the abandonment two years ago of the Bessemer department at the Duquesne Steel Works, are suggestive of the changed status of the Bessemer converter as compared with the open-hearth steel furnace. Engineers practically refuse to take Bessemer steel plates, and the tonnage of Bessemer structural shapes acceptable is restricted. Bessemer steel still has usually the call for tin plates, sheets, wire products and pipe, while in rails it has a contest.

Unfinished steel is scarce, and market transactions are limited. Billets are quotable nominally at $27, Pittsburgh, and sheet bars at $28 to $30, the latter being for next year's delivery. Rods are about $32.50, Pittsburgh.

Finished Materials.

Steel bars are quoted at $1.50 and plates and shapes at $1.60 by all the independent producers, but the Steel Corporation subsidiaries have been selling in a limited way at a dollar a ton less to old customers and for definite requirements, the action being due to an effort to forestall a too rapid advance in prices.

On Nov. 12 the American Sheet & Tin Plate Company announced the following price advances:

Tin plates, $3.50 to $3.60 for 100-lb. cokes.

Blue annealed sheets, $1.70 to $1.75 for No. 10 gage.

Black sheets, $2.40 to $2.50 for No. 28 gage.

Galvanized sheets, $3.35 to $3.50 for No. 28 gage.

Painted corrugated roofing, $1.60 to $1.70 per square for No. 28 gage, 2½ in. corrugations.

Galvanized corrugated roofing, $2.85 to $3 per square for No. 28 gage, 2½ in. corrugations.

The above advances were promptly followed by the independents, except that in blue annealed the independents advanced to $1.80 as they are able to make fairly prompt deliveries, the leading interest promising deliveries on this material only in about three months.

Other prices stand as follows, f.o.b. Pittsburgh, except where otherwise noted:

Steel bars, $1.45 to $1.50, base.

Iron bars, $1.70 to $1.75, base, f.o.b. Pittsburgh mill; $1.55 to $1.60, Chicago; $1.60 to $1.70, Philadelphia.

Plates, $1.55 to $1.60.

Shapes, $1.55 to $1.60.

Standard rails, $28 for Bessemer and $30 for open-hearth, f.o.b. mill, except Colorado; light rails 25 lb. to 45 lb., $27 to $28.

Merchant pipe, extreme discount, 80 and 5 off list for steel; 74 and 5 off for iron.

Plain wire, $1.60; wire nails, $1.80, base; painted barb wire, $1.80; galvanized barb wire, $2.10; foregoing prices to jobbers for specifications within 30 to 60 days; wire to manufacturers, delivery over first half, $1.70, base.

Testing of Electrical Instruments at the Bureau of Standards.

We have received from the Bureau of Standards, in Washington, D. C., Bureau Circular No. 20 on the "Testing of Electrical Measuring Instruments."

The first 22 pages are an excellent, concise review of the principles, applications and limitations of various electrical instruments. This review is worth careful reading by every user of electrical instruments. Direct-current and alternating-current instruments are covered, also integrating instruments, recording instruments, accessory apparatus, including instrument transformers, sources of error, reliability of electrical instruments and apparatus for checking instruments.

This part of the bulletin is a very useful, concise and clear exposition of the fundamental principles of construction and application of the various commercial electrical measuring instruments and deserves the widest distribution among users of instruments.

The second part of the bulletin contains the regulations for instrument tests at the Bureau of Standards, with general instructions, schedule of fees, and notes on special tests and measurements.

The circular will be sent to anyone upon request. All communications should be addressed to the "Bureau of Standards, Washington, D. C."

CORRESPONDENCE.

Drying.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—I have read with great interest the very thorough technical article upon drying, in your November number, by John Jermain Porter. This article shows a great amount of care and knowledge in its preparation. I wish to take exceptions, however, to some of his conclusions, which, I believe, are due to wrong premises.

The article states that the maximum efficiency is obtained when the theoretical amount of air is used in consuming the fuel. Other things being equal, this is undoubtedly true; but in burning ordinary coal with the theoretical amount of air, a temperature of 4500° Fahr. to 5000° Fahr. would be obtained, so that even were this possible, firebrick, cast iron and steel, used in the construction of a dryer, would be melted down like wax. The only practical way to burn fuel for drying purposes is to admit about three times the theoretical quantity of air so that the temperatures do not exceed 1500° Fahr.

The article also states that "the presence of hydrogen in fuels decreases materially their value for drying purposes." This would undoubtedly be true if, as the article assumes, the drying should all be done by absorption of moisture by the air. As a matter of fact, the loss in heat, due to the formation of water by the combustion of hydrogen, is less than 17 per cent of the total heat generated, and as the amount of hydrogen in ordinary coal is about 5 per cent, the total loss of heat due to hydrogen in the coal, amounts to less than 1 per cent of the total calorific value of fuel, which is a neglectable quantity compared with other losses. The amount of moisture absorbed by the air is a very small proportion of the amount driven off in drying of inorganic substances. The temperatures at which drying is done is considerably above 212°, so that most of the water passes off as steam or watery vapor and a very small proportion is absorbed by the air. Should we depend only upon absorptive power of the air, the capacities which could be obtained in drying would be exceedingly small.

The article states that "in a counter-current dryer the solid dried materials must pass out at a temperature approximating, or equal to, the temperature of the gases of combustion as they enter the dryer." This is only true when very small capacities are required, and where very high temperatures are desired. The writer has seen scores of counter-current dryers in which the temperature of the entering products of combustion was 1200° Fahr. or greater, while the dried material being delivered was not over 230°. Therefore, the contention of the article that the great loss of specific heat of the material made such a dryer more wasteful in fuel than the "parallel-current" dryer cannot be maintained. As the products of combustion pass through the cold material before going to the stack, the temperatures can be reduced to 100° Fahr. or less, so that a greater saving can be made in this way, more than counterbalancing the greater heat carried out by the dried material. With a "parallel-current" dryer, in which the material flows in the same direction as the products of combustion, the exhaust temperatures of the escaping gases and steam must be above 212° Fahr. or recondensation takes place and the drying material will be delivered wet.

The article speaks of the loss of heat by radiation merely in the formulas, but does not mention what this may possibly amount to. As a matter of fact, one of the greatest losses in drying material is due to this cause, and the writer has made tests where this radiation amounted to over 50 per cent of the calorific value of the fuel, and in any single-shell dryer, which the article assumes to be the only type, the loss in this way is never less than 35 per cent.

A well-known dryer is being made in which the loss of radiation is not over 7 per cent; the loss by the exhaust temperature of the air not over 8 per cent, and the loss by the specific heat of the dried material not over 5 per cent, so that a total efficiency of 80 per cent is obtained from the fuel, against about 46 per cent in the ordinary old style of single-shell machines.

New York City. W. B. Ruggles,
President, Ruggles-Coles Engineering Company.

* * *

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—In replying to Mr. Ruggles' letter criticising my article on direct-heat dryers, I wish to emphasize the fact that the paper was intended only as a theoretical study and necessarily involved some assumptions which will not hold true in practice.

Mr. Ruggles' first criticism is well taken from his standpoint, it being impracticable for several reasons to burn fuel with the theoretical quantity of air.

With regard to the second criticism, it is true that the quantity of hydrogen in coals is so small as to be unimportant, but this is not true of some of the gaseous fuels, for example, natural gas and water-gas. I might state in this connection that this paper is the outgrowth of calculations and experiments which were made to determine the relative value of coke and natural gas as fuels for a set of core ovens.

With regard to the third criticism, it is, of course, true that if a perfect heat interchange is not effected, the formula will not hold true. However, it is also true that if the waste gases are reduced to a temperature of 100° Fahr. the amount of water evaporated is limited by the amount which will saturate the gases at that temperature and it is difficult to see how this condition could be conducive to efficiency.

The fourth criticism is, I think, answered sufficiently by the statement that the paper was intended only as a theoretical study.

In conclusion, I wish to say that I regard Mr. Ruggles' comments as a valuable contribution to the literature on dryers, and I feel some satisfaction in having been the indirect cause of its production.

University of Cincinnati. John J. Porter.

NEW YORK MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY

It is a pleasure to report the great success attained at the sixteenth general meeting of the American Electrochemical Society, which was held in New York City on Oct. 28, 29 and 30.

Since 1906 the autumn meeting has always been held in New York, this arrangement having been found advisable four years ago for the following reasons: At that time many members thought that two general meetings a year were one too many, and it was proposed to hold only one annual meeting. As this would, however, have meant the publication of only one volume of *Transactions* a year instead of two, the usefulness of the society would have been very seriously impaired.

It was then decided to adopt a compromise plan—namely, to hold one large annual meeting each spring, at different places from year to year, and another meeting of secondary importance each autumn in New York City. It was thought that many members, not residing in or near New York, would anyhow come to New York for business reasons some time in autumn and could easily arrange the date of their visit so that they would attend the meeting of the society. Aside from this, the success of the New York meeting would be assured by the very large membership of the local section.

So far the plan has worked very well. Since 1906 the spring meetings have been held in Cornell University, Philadelphia, Albany-Troy-Schenectady, and Niagara Falls; they all were exceedingly enjoyable and immensely successful. On the other hand, the first New York autumn meeting, in 1906, represented a decided minimum point in the career of the society; it proved of even less interest than the most modest advocates of an annual New York autumn meeting had expected. Everything was changed, however, in the autumn of 1907, when the New York Section, at its request, took hold of the New York meeting and made it a full success. This was repeated in 1908, while a decided climax was reached in the most enjoyable meeting just closed. The original plan of making the New York meeting of secondary importance only had, however, now been completely lost sight of.

Of course, it was but natural that with a highly distinguished and energetic New Yorker, Dr. L. H. Baekeland, as president of the national society, New York should make a special effort this year. While all New York members contributed to the success, credit is principally due to Dr. Baekeland and to the indefatigable secretary of the New York Section, Mr. Alois von Isakovics, while the general arrangements, especially of the professional sessions, were, as ever, very well taken care of by the secretary of the society, Dr. J. W. Richards, of Lehigh University.

There were three professional sessions, detailed reports of which will be found below. The first session, on Thursday afternoon, was held in the lecture hall of the Chemists' Club, the two sessions of Saturday morning and afternoon at Earl Hall, Columbia University. All sessions were well attended.

Excursion to Bayonne.

The whole of Friday was devoted to an excursion to the principal chemical and metallurgical industries of Bayonne, N. J., where a party of more than 300 was taken by a special train of the Central Railroad of New Jersey. As the Mayor of Bayonne, Hon. Pierre P. Garven, explained in welcoming the party to the city at luncheon at one of the finer resorts, Bayonne is a rapidly growing industrial center with great commercial possibilities on account of its enormous waterfront on the Kill von Kull, and on New York Bay and Newark Bay.

During the morning visits were paid to various plants on

PHOTOGRAPH TAKEN AT CONVENTION OF AMERICAN ELECTROCHEMICAL SOCIETY

Tonawanda Hook [illegible] the acid works of the Standard Oil Company were first visited, where sulphuric acid is made from Spanish pyrite by the lead-chamber process. The fumes proved pretty irritating to some of the visitors and fresh air was a decided relief.

A small section of the National Sulphur Company was then visited (flowers of sulphur). The plant of the Pacific Coast Borax Company was next in line. The visitors were shown the methods of manufacture from the raw materials through the crystallizing tanks to the packing department, where lump and powdered "twenty mule team" borax is put up in barrels. Boric acid is also made on a large scale.

The oil refineries of the Standard Oil Company afforded an excellent opportunity to study exhaustively modern methods of barrel making, both wood barrels and steel barrels or drums. Of the oil refinery proper the paraffine end of the works was shown, and samples of the final residue, after the petroleum processes have been completed, were inspected. This residue is about 95 per cent pure carbon. It is largely used in the manufacture of electrodes.

The last visit of the morning was made to the Gröndal briquetting plant at the works of the General Chemical Company.

L. H. BAEKELAND, PRESIDENT AMERICAN ELECTROCHEMICAL SOCIETY.

This is the first American installation of this process and has been in operation but a few months. It seems to be almost a duplicate of the one in Sweden, described and illustrated in our Vol. IV, page 510. Imported pyrite is used, the material briquetted being the residue after the sulphur is driven off in the manufacture of sulphuric acid. This residue is very rich in iron oxide, but in its disintegrated form it is unsuitable for the blast furnace. The briquets, however, can be satisfactorily used.

The first plant visited in the afternoon was that of the Babcock Wilcox Boiler Company. This is a big and modern works and is still being added to. The administration building has been finished about a year ago, and contains the various engineering and draughting divisions, accounting, and, in fact, all the offices, as well as a finely equipped chemical laboratory and an interesting physical testing laboratory with apparatus for metallographical experiments.

In the plant were shown various boilers in course of construction, all of the standard Babcock & Wilcox water-tube type and built up of sectional units in the usual manner. The punching, shearing and drilling machines and the bending rolls for the cylindrical receivers were interesting. The automatic chain-grate stoker is also constructed here and could be seen in operation in the power plant. Power distribution is by electricity and compressed air for the riveters, hoists, etc. Five guides, were provided and definite routes carried out. The Babcock & Wilcox Company have another plant, of about the same size, in Ohio.

The last plants visited were those of the Electro-Dynamic Company, the Electric Launch Company, and the Industrial Oxygen Company, all three plants being near the Avenue A Station.

The specialty of the Electro-Dynamic Company is the manufacture of interpole motors in various sizes. All the processes of manufacture could be readily seen and some of the finished motors were on test. The "interpole motor" is exceedingly valuable in industrial works, where wide speed variations and heavy load fluctuations are the rule. The feature of the interpole motor is that under such severe conditions there will be no sparks at the commutator.

JOS. W. RICHARDS, SECRETARY AMERICAN ELECTROCHEMICAL SOCIETY.

The Electric Launch Company manufactures electric and gasoline launches of all designs and sizes. Several boats were in storage and some in course of construction.

At the plant of the Industrial Oxygen Company the processes of welding and cutting by means of the oxy-acetylene flame were demonstrated. An adjoining building contains a generating plant for the production of oxygen from oxygenite. An illustrated description of the interesting process of this company was given on page 431 of our Vol. VI.

The party returned then by their special train to New York.

Social Features.

In the evening of Friday a very enjoyable subscription dinner was held at the Hotel Cumberland. It was very well attended, with a large number of ladies in the party. Dr. Doremus was a forceful toastmaster, and speeches were made by President Dr. Leo H. Baekeland; by Professor Armstrong, of London, for the Faraday Society of Great Britain; by Dr. William H. Nichols, as the president-elect of the International Congress of Applied Chemistry, to be held in 1912 in this country; by Dr. William R. Whitney, as president of the American Chemical Society; by Dr. Morris Loeb, as president of the Chemists' Club; by Mr. Maximilian Toch, as chairman of the New York Section of the Society of Chemical Industry; by Dr. J. W. Richards, as secretary, and by Dr. H. W. Wiley, who made a great hit with his bachelor toast on the ladies.

ALOIS VON ISAKOVICS, SECRETARY NEW YORK SECTION, AMERICAN ELECTROCHEMICAL SOCIETY.

In the evening of Saturday the society was the guest of the Chemists' Club at a smoker in the clubhouse. Mr. Maximilian Toch showed some very interesting and amusing lantern slides made from photographs taken on the trip last summer of many American chemists to the International Congress in London.

Special mention should be made of the elaborate arrangements which the local ladies' committee, under the chairmanship of Mrs. L. H. Baekeland, had made for the entertainment of visiting ladies. The program included a reception and tea by invitation of Mrs. William H. Nichols at the Waldorf-Astoria on Thursday afternoon, an automobile ride and tea at the Claremont on Friday afternoon, and a theater party on Saturday.

Titanium Arc.

The first paper of the Thursday session was presented by Dr. WILLIAM S. WEEDON on an investigation carried out several years ago in the research laboratory of the General Electric Company. The work covered a large number of elements, compounds, and mixtures, with considerable variation in the method of preliminary treatment, as to their suitability for arc-lamp electrodes.

Among the substances that were tried there was none which gave as high an efficiency in candle-power per watt as material which contained the element titanium. The titanium arc is suitably formed between a titanium carbide cathode below a copper anode. The latter is inactive and does not waste appreciably. The titanium arc is a flame arc, and its efficiency increases with increase in current density and with increase in arc length.

At 3 amp. 103 volts and 1-in. arc length, it consumes only 0.228 watt per horizontal candle power. The mean spherical candle-power at 2.87 amp, 95 volts (273 watts) is 535, and the mean hemispherical candle-power 737.6. On this basis the power consumption is 0.51 watt per mean spherical candle-power, and 0.37 watt per mean hemispherical candle-power; this corresponds to a yield of 1.96 mean spherical candle power, or 2.70 mean hemispherical candle-power per watt. The electrical measurements were made at the arc terminals and the photometric measurements were made through a clear-glass globe of the usual thickness.

A study of the efficiency curves shows that titanium-carbide arcs are most satisfactorily operated on a constant-current circuit rather than on a low-voltage multiple circuit (with the necessarily short arc length). The author gave pictures of various flame arcs, and then described the preparation of the titanium-carbide electrodes. The lump material is coarsely powdered and then pulverized in a ball mill to a high degree of fineness. It is then worked in a roller mill with oil, glycerine or other suitable binder. After the material is thoroughly plastic it is extruded through a nozzle by means of a hydraulic press, the sticks being cut to suitable lengths.

After drying at ordinary temperatures, and then in a gas oven, the electrodes are fired at high temperature, preferably in an electric furnace of the carbon-tube type. After firing, the sticks should be firm and without cracks. If fired at too high a temperature they are liable to be brittle. The titanium-carbide arc may also be operated with alternating current under certain conditions.

The author finally referred to some experiments with the titanium suboxide arc, which can be operated only with direct current. The material used in these experiments was prepared in the electric furnace by the reduction of rutile. Its preparation is quite easy, since the melting point of the product is much lower than that of the carbide.

The character of the arc is almost identical with that of the carbide arc, but the light is much steadier. There are certain objections to this electrode, and among them are the tendency to form large troublesome deposits on the anode and the fairly rapid consumption of the suboxide stick.

The suboxide gives a light efficiency even better than the carbide. At 3.4 amp, 7/8 in. arc length and 100 volts 2100 candles (horizontal) are obtained. This gives a power consumption of 0.162 watt per horizontal candle-power, or a yield of 6.17 horizontal candle-power per watt. The distribution of the light is the same as with the carbide.

The heavy deposit on the anode is probably responsible for the fact that the difference in potential between the terminal is about 15 volts higher than is the case with the carbide at equal arc length and current.

In the discussion which followed, Dr. Whitney, the head of the research laboratory of the General Electric Company, explained that the paper had been finished in 1904, but that it had to be withheld from publication for commercial reasons. He referred to Tumlirz and Angstrom's figures for the electrical equivalent of light. Tumlirz's figure for the theoretically maximum efficiency is 0.188 watt per spherical hefner candle-power; Angstrom's figure is 0.102 watt per spherical hefner candle-power) and emphasized that with the titanium arc we are getting quite a deal nearer to theoretical maximum efficiency.

Professor Tucker thought from some experiments he had made that zirconium carbide might be found even more efficient than titanium carbide. But Dr. Weedon denied this. Dr. J. W. Richards said that the hypothesis had been offered that the heat set free in the oxidation of the electrode might account partly for the high efficiency, but he explained that from the calculations which he had made for this, it can only play a very small part. Mr. Shimer had been the first to isolate titanium carbide from steel. Dr. Weedon said that they had tried almost every carbide, but titanium carbide was the most efficient.

In such experiments the direction of the current may have an important effect on the results.

Boron.

Dr. E. WEINTRAUB reported in a paper on an experimental research extending over several years and carried out at the Research Laboratory of the General Electric Company by the author with the assistance of E. Kraus and G. Weintraub. The properties of pure boron have so far been unknown, since the only material heretofore produced and alleged to be pure boron was in the form of an amorphous powder. The object of Dr. Weintraub's research was to produce pure boron in fused homogeneous form. (The investigation formed part of a research for elements suitable as a material for incandescent-lamp filaments.)

Reaction Between Boric Anhydrite and Magnesium.—This reaction was first studied since it was the starting point of Moissan's work. But Dr. Weintraub found that, however the conditions of the experiments might be changed, no homogeneous product was obtained. There was always a mixture of a dark product rich in magnesium and a brown product supposed to be boron.

The difference in composition and appearance between parts of the same fusion could only be accounted for by assuming differences in temperature. The brown material was found to prevail in the center of the mass, where the temperature is highest; the dark product, on the outside of the mass, where the temperature is lowest.

The brown substance, being apparently the product of the reaction at a higher temperature, two methods were recurred to for the purpose of production of a uniform brown fusion, namely, first, using a higher temperature furnace (an electric furnace, for instance), second, carrying out the reaction in an ordinary gas furnace on a large scale so that the temperature *inside of the mass* can attain a high value on account of the heat of the reaction itself.

Both methods led to the expected result. When a large crucible is charged with a kilogram or more of the reacting mixture the resulting fusion is of a uniform brown color throughout, except for a thin layer on the very outside, which could be easily removed.

After removal of this thin outside layer and the usual chemical treatment of the mass, the resulting powder was of a somewhat lighter color than the one obtained in following Moissan's descriptions, showing the absence of the dark magnesium boride, and analysis showed only 0.11 per cent magnesium instead of 3 per cent to 4 per cent, found when the reaction is carried out in the old way.

The preparation of a product practically free from magnesium has thus been achieved. Dr. Weintraub expected to find pure boron, but the analysis of the product gave only 83.2 per cent boron instead of 88 per cent to 90 per cent found in the product obtained in the old way. This was a surprising result.

The sum of all the elements determined (including boron nitride and traces of iron) was only in the neighborhood of 85 per cent and 15 per cent were unaccounted for. In the product obtained in the old way the sum differed from 100 by 4 per cent to 5 per cent. The question, therefore, arose what the impurity in the brown product, free from magnesium, might be. It could have been water, or admixed boric anhydride, or hydrogen introduced during the acid treatment (in which case the substance would be a complex boron hydride) or oxygen (in which case the substance would be a complex boron suboxide). The first three possibilities were disproved.

There remained only the fourth possibility, which was also proved to be correct directly by experiments. There was first some difficulty in finding a definite proof for the presence of oxygen. The method finally used for the proof of the existence of oxygen in the boron powder was based on the oxidizing action of potassium permanganate. The reducing action of boron on potassium permanganate was noticed by previous experimenters, notably by Moissan, but Dr. Weintraub found that with the boron obtained in the reaction between boric anhydride and magnesium, this reduction could be carried out in a quantitative way, so much so that a regular titration method could be developed.

A simple reasoning shows that if the impurity in the boron is oxygen in any form the consumption of permanganate would be less than that corresponding to the content in boron, since a part of the boron is in an oxidized condition beforehand. In the case of any other impurity the permanganate titration and boron determination should agree. The application of this method proved clearly that the brown substance, free from magnesium, contains oxygen. Dr. Weintraub calls it boron-suboxide for the sake of brevity.

He further studied the question whether the substance is homogeneous or a mixture of different compounds. In his first series of experiments he varied the conditions under which the substance was produced and investigated whether this changed the composition and properties

The result of the variation of temperature and ratio between boric anhydride and magnesium can be summarized in the following three statements:

1. Low temperature and low ratio of boric anhydride to magnesium favor the formation of boron containing large quantities of combined magnesium.

2. High temperature and a high ratio of boric anhydride to magnesium favor the formation of boron free from magnesium, but containing oxygen in form of suboxide.

3. If the excess of boric anhydride becomes too large it acts as a diluent and by lowering the reaction temperature leads to the formation of products containing both oxygen and magnesium

By varying the conditions in such a way as to obtain products with only a small percentage of magnesium the composition of the suboxide was found not to vary much. In all cases a product is obtained containing 82 per cent to 85 per cent boron and 16 per cent to 14 per cent oxygen.

The author then, also, employed a second method in which the substance was submitted to different chemical treatments to see whether any separation of the substance into different parts would take place. Partial titration with permanganate was tried. The oxidation was carried out in different stages and the residue analyzed every time. But the residue had always approximately the same composition as originally. Assuming that a chemical individual is present, Dr. Weintraub concludes that the corresponding formula would be $B_{35}O_2$, or perhaps B_2O

Dr. Weintraub then tried to re fuse the brown substance thus obtained with a large excess of boric anhydride in order to produce pure boron, but he did not succeed. Other analagous experiments in which the reduction of boric anhydride by means of calcium, aluminium, etc. (instead of magnesium) was studied, gave even worse results.

Reduction of Boron Halides by Hydrogen.—The reaction between boron chloride and an excess of hydrogen—which has first looked little promising, proved to be the solution of the problem. In the first experiments it appeared, however, that when the reduced boron would come in contact with the hot walls of the furnace, for instance, with the walls of a silica tube at very high temperature, the silica would react with the boron. This is a general and interesting reaction between boron and oxides, like silica, alumina, magnesia, at very high temperatures. Around 2500° magnesium oxide is reduced by boron (while below 1600° boron anhydride is reduced by magnesium).

The solution, therefore, depended on the use of a very high temperature without bringing the produced boron in contact with the hot walls; this is accomplished by an arc discharge through a mixture of boron chloride and hydrogen.

The substances, boron chloride and hydrogen, are both gaseous at room temperature. The reaction products consist of one gaseous substance, hydrochloric gas, and one solid produce, namely, the desired element, boron.

The separation of this product would, therefore, offer no difficulties whatever.

The experiments soon revealed the advantages of the method. The blast of the arc removes the produced solid particles of boron out of the zone of the reaction by throwing them out onto the cold walls of the vessel or the cold electrodes. The reaction between boron chloride and hydrogen is a reversible one, as is shown by the fact that boron chloride can be produced by passing hydrochloric gas over boron heated to red heat. To insure a good yield in the reduction of boron chloride by hydrogen, it is, therefore, desirable to remove the boron as rapidly as possible from the very hot zone of the area, where the reduction takes place. The mechanical blast of the arc accomplishes this automatically. In this the reaction between boron chloride and hydrogen has the advantages over the reaction leading to nitric acid from nitrogen and oxygen.

A serious difficulty was the disintegration of carbon or graphite electrodes whereby the boron was contaminated. This difficulty was overcome by the use of copper electrodes, which do not disintegrate, while the affinity of copper to boron is exceedingly slight.

The method finally developed consisted accordingly in running one or more alternating-current arcs, fed by a high-potential transformer, between water or air-cooled copper electrodes, in a mixture of boron chloride with a large excess of hydrogen in a glass or copper vessel.

This boron is partly thrown off in the form of fine powder onto the walls of the vessel or onto the electrodes. It partly settles on the ends of the electrodes, where it grows in form of small rods. After a while the arc thus runs between two boron electrodes, and if the current of the arc is of proper value the rods melt down to boron beads, which eventually fall off, whereupon the same process repeats itself.

The product obtained consists, therefore, partly of powder and partly of fused lumps. The powder has to be washed with water to remove a small amount of boric anhydride, the formation of which is due to traces of air set free from the electrodes and the walls of the vessel. After the small amount of boric anhydride mixed with the powder is thus removed, the analysis gives 99 per cent to 99.5 per cent boron.

As neither copper nor hydrogen could be detected in the powder, the missing 0.5 per cent to 1 per cent may possibly be due to presence of a small amount of boron suboxide. It seems, in fact, impossible, unless very exceptional precautions are taken, to avoid oxygen in the gases, and possibly traces of boron oxychloride in the boron chloride used. As the permanganate titration does not give quantitatively with boron produced under these circumstances, the presence of a small amount of boron suboxide could not be proven.

The fused lumps of boron analyze from 99.8 per cent to 100.2 per cent. The difference from 100 is due to a trace of

silica which is introduced into the boron during the process of pulverization in the agate mortar and to the unavoidable analytical errors. Both the method of formation and the analysis proved the absolute purity of the fused lumps of boron.

The yield obtained is the greater the larger the excess of hydrogen used. Naturally, however, the amount of boron obtained per unit of time is the less. The yield is also the greater the larger the surface of contact between the arc and the gas. A number of arcs in the same vessel or in vessels mounted in series is, therefore, advantageously used. The best yield ever obtained by Dr. Weintraub in one vessel was 50 per cent of the theoretical. As a rule, however, 30 per cent can be considered satisfactory, and at the same time a reasonable speed of boron formation is obtained.

The boron chloride can be condensed out of the escaping gases and used over again.

The mixing of the gases can be carried out either by passing hydrogen over the surface of boron chloride placed in a vessel surrounded by a refrigerating mixture or by allowing boron chloride to drop into a vessel, kept a little above room temperature, through which hydrogen is passed.

In the arrangement of the arcing apparatus all the well-known modifications, such as use of a magnetic field, the introduction of gases through the electrodes themselves, etc., can be applied.

The boron powder obtained in the process can be purified and fused down by two different methods developed in the course of this investigation. These methods are very valuable in the treating of refractory materials and have become regular tools in the research laboratories of the General Electric Company.

Their purpose is to treat or melt refractory materials under conditions where no contamination with foreign material is possible.

The first consists in the use of a mercury arc either in vacuum or in an indifferent gas, and is best applicable to materials having an appreciably high conductivity. It is based on the evolution of heat which takes place at the anode of a mercury arc (constant voltage drop multiplied by current) and of the fact that most refractory materials, such as tungsten, tantalum, boron, etc., have no affinity whatever to mercury. The arrangement, which is used in a large number of modifications, can be termed a *mercury-arc furnace*.

The second method is based on the use of a high potential arc in an indifferent gas and is especially applicable to the treatment, purification and melting of substances possessing only a very slight conductivity. This method was especially used in this boron investigation and is one of the methods used in the experiments on the dissociation of boron compounds described below.

Physical Properties of Pure Boron.—The melting point and the sublimation point of pure boron lie near together and between 2000° C. and 2500° C.

Under atmospheric pressure boron readily melts. In vacuo boron first volatilizes, more and more rapidly as the temperature is raised, until, apparently under the pressure of its own vapors, it begins to melt. When once the surface is thoroughly fused, the tendency to volatilize is greatly reduced and then the boron can be fused in vacuo with only a small loss in weight.

The accurate determination of the melting point could probably best be carried out by melting boron in hydrogen by means of a high-potential arch, the use of which is mentioned above. Dr. Weintraub has not attempted this determination; he takes his estimates of its being between 2000° C. and 2500° C. from rough comparison of brilliancy of surfaces.

The considerable vapor tension of boron, which begins to show itself in blackening the walls of the exhausted globe, already at a temperature of 1600°, makes boron as such useless as a material for incandescent filaments.

In hardness fused boron is inferior only to diamond.

The fracture of pure fused boron is conchoidal, showing no signs whatever of micro crystalline structure. In this boron greatly resembles diamond.

It differs, however, considerably from the good specimens of black diamond in its toughness or strength. To the tremendous pressure under which diamond is formed, its characteristic toughness is usually ascribed and it is probable that if boron were fused under great pressure, it would acquire similar characteristics.

For the purpose of artificial production, which has not as yet given practical results in the case of diamond, the conditions are more favorable in the case of boron on account of its considerably lower melting point.

Dr. Weintraub then discusses the most interesting property of fused boron, namely, its *electrical conductivity*. At ordinary temperature boron is a very poor conductor, but its conductivity rises with the temperature with a very exceptional rapidity. Between room temperature (23° C.) and dull red the conductivity of fused boron increases about 2,000,000 times, a rate of increase unknown in any other element with the possible exception of selenium in the narrow range below the melting point of the latter. Above dull red the resistance still continues to go up very rapidly, and at bright-red heat boron is a relatively good conductor.

A similarly great fall in resistance is exhibited by oxides at temperatures above red heat; boron shows this behavior around room temperature, where quantitative study of the relation between temperature and resistance is possible.

For small intervals of temperature, the resistance drops geometrically for equal temperature differences; in other words, as a first approximation for not too large intervals of temperature, the resistance is an exponential function of the temperature. Around room temperature, the interval of temperature for which the resistance drops to half its value is about 17°. This interval slowly increases and is nearer 30 per cent around 300° C. Below is given one set of resistance measurements. This table has no pretentions of being accurate, as

Temperature.	Resistance in ohms.
27	5,620,000
45	2,590,000
60	1,500,000
70	1,060,000
80	758,000
90	560,000
100	395,000
110	285,000
120	238,000
130	194,000
140	134,000
150	107,000
160	77,000
170	55,000
180	46,000

very slight errors in the temperature determination cause very great differences in the resistance. For this reason two sets of measurements never completely agreed.

The measurements at high temperatures are rendered some-

Temperature.	Resistance.
140°	107,000
160	55,000
170	40,000
180	30,500
190	22,000
210	13,000
220	10,700
250	5,300
270	2,900
290	2,250

what uncertain not only by the factors mentioned above, but also by some thermal emfs of small magnitude, the origin

of which has not yet been elucidated. Thus, in a second set of measurements, which agreed fairly well at lower temperatures, large discrepancies appeared at temperatures above 100°. The next table carries the measurements up to 300°.

Finally, the same piece of boron was put into an exhausted globe and the measurement continued to see how far the resistance would drop. At beginning red (visible in a darkened room) the resistance was only 5 ohms. Thus between 27° and beginning red heat the resistance of the boron piece dropped 5,800,000 ohms to 5 ohms. The values at the lower temperature are certainly too low on account of the heat developed by the small current (1 1,000,000 amp). This is especially serious on account of the high resistance of boron, which makes the energy dissipated high even at very small currents, and on account of the small specific heat capacity of boron.

The determination of the specific resistance of boron from these measurements is somewhat difficult on account of the irregular shape of the lumps used. At 23° C. the specific resistance has the approximate value of 1.7×10^4, or about 10^{12} times that of copper.

Toward applied moderate voltages boron behaves, however, as a relatively good conductor on account of the change in resistance which takes place automatically and rapidly.

A substance with such remarkable electrical properties is naturally capable of a number of technical applications, of which the following were mentioned by Dr. Weintraub: as a motor-starting device; a sensitive pyrometer and bolometer; a wireless detector; a compensator for positive resistance changes to temperature, etc. The hardness of boron, combined with its conchoidal fracture, make it applicable to the use as jewels, dies, etc. All these technical applications are now in development.

Dissociation of Boron Compounds.—The author also studied three methods of preparing pure boron by dissociation of boron compounds at high temperatures.

1. *Magnesium boride* and similar compounds (obtained in the reaction between boride anhydride and magnesium when the first is not in excess). The dissociation begins at relatively low temperature (1200°), especially in vacuo, and is quite rapid at 1500°.

2. *Boron suboxide* (obtained in the reaction between boric anhydride and magnesium when the first is used in excess and a high temperature applied). The dissociation begins only at high temperature and is accompanied by volatilization of a part of boron suboxide (especially if it is carried out in vacuo).

3. *Boron nitride*. The dissociation of this compound only takes place at a very high temperature.

If the dissociation of these compounds is carried out in ordinary electric furnaces where the heating element is carbon, the obtained product is contaminated somewhat with carbon.

New types of furnaces have been developed in which no carbon heaters are used, or else in which the product is protected from the carbonaceous vapors.

Preparation and Properties of Solid Solutions of Carbon and Other Elements in Boron; Chemical Metallization of Carbon.—After pure boron in fused form had been prepared and its properties ascertained, an investigation was started on the influence of small amounts of other elements dissolved in boron. Carbon, silicon, magnesium, aluminium, etc., were tried. Dr. Weintraub described only the properties of solid solutions of carbon in boron as perhaps the most remarkable of all.

If carbon is introduced into boron in small amounts the cold conductivity is enormously raised and the negative temperature coefficient of resistance reduced. The effect is so great that it is not an easy matter to get accurate results. The magnitude is shown by Dr. Weintraub's statement that a few tenths of one per cent of carbon reduce the cold resistance of boron in the ratio of 12:1.

Between pure boron and boron containing about 8 per cent carbon there is a most interesting region in which almost any desired negative temperature coefficient of resistance can be selected.

The specific resistance goes down as the carbon content increases, which may be very advantageous for many practical purposes.

Above 8 per cent the temperature coefficient is of a magnitude which can be found readily in other substances.

The solid solutions of small amounts of boron in carbon exhibit still more remarkable properties.

All the known forms of carbon which conduct at all, whether amorphous carbon or graphite or carbon made by carbonizing cellulose (base of a carbon filament in incandescent lamps) or deposited from volatile hydro-carbons, have a negative temperature coefficient of resistance.

The only exception is formed by the so-called "metallized" carbon produced by the General Electric Company by heating carbon deposited from gasoline to a very high temperature in an appropriate electric furnace.

This species of carbon has a relatively low specific resistance and a positive temperature coefficient of resistance.

The same change in the properties of the carbon is produced, as Dr. Weintraub found, by incorporating into it a very small amount of boron, an amount so small that it can be detected only by flame reaction, but cannot be determined analytically; in other words, *boron has a catalytic effect, transforming metalloidical carbon into metallized carbon.*

This effect must not be confused with the well-known graphitizing action which a large number of elements have on carbon. In the case of graphitization a material is produced which drops in resistance with increase of temperature.

The metallizing action of traces of boron is specific to this element. All other elements tried, particularly iron and silicon, do not produce that result.

Whatever the cause of the peculiar action of boron, it is established that by its means the *chemical metallization* of carbon is accomplished for the first time.

It is remarkable that a substance like boron with an enormous negative temperature coefficient of resistance, when dissolved in traces in carbon, which also has a negative temperature coefficient of resistance, transforms the latter into a positive one.

Dr. Weintraub had a very interesting exhibit of various preparations of boron. The president, Dr. Baekeland, in opening the discussion, complimented Dr. Weintraub highly on his achievement. Mr. Hering asked how the boron wire exhibited had been made.

In his reply Dr. Weintraub explained that it had been produced by first making a rod by compressing, then sintering it and then depositing boron from boron chloride and hydrogen as described.

Silundum.

Prof. S. A. Tucker presented a paper by himself, H. F. Kudlich and E. M. Heumann on the preparation of silundum. Bölling's original paper on making silundum was published in this journal, January, 1909, page 24. The method employed by Bölling for converting carbon into silundum consists in heating the carbon in an atmosphere of silicon, the combination of the two producing carborundum, which is absorbed to varying depths by the carbon, depending upon the temperature and the length of time. The present authors studied the formation of silundum according to the following two reactions, yielding silicon, as the preparation of silundum appears to depend on a formation of silicon:

$$SiO_2 + 2\,SiC = 3\,Si + 2\,CO,$$

and

$$SiO_2 + 2\,C = Si + 2\,CO.$$

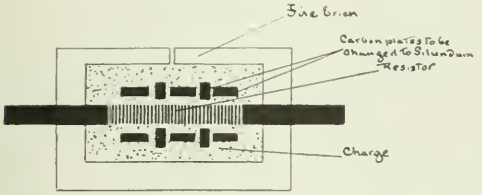
The furnace is shown on page 513. It is built of firebrick. The core instead of being of granular carbon was made by pressing together a number of small carbon plates between two horizontal graphite electrodes; the plates were 2½ in. x 1¼ in. x ¼ in. pressed together face to face. Around their core was placed

a charge of sand and carborundum in which were imbedded at varying distances from the core the carbon articles to be changed to silundum.

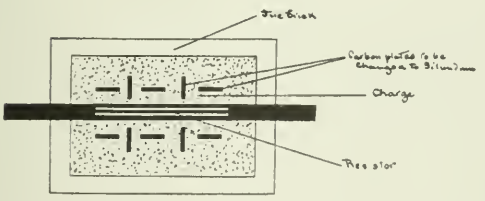
The side and end walls of the furnace were concreted as tight as possible in order to prevent the ingress of air, which would tend to oxidize the silicon as it was formed. The authors described the results of eight different experiments from which it is evident that silundum can be produced by either of the two reactions mentioned above; the second reaction, employing cheaper materials, would naturally be preferable. The temperature employed seems to be about the same as that for the preparation of carborundum.

The penetration or conversion of carbon into silundum depends upon the time of the run and also on the temperature employed. The conversion of the carbon into silundum depends upon its position with respect to the core. No very careful study was made of the product; the following points were noted, however.

In appearance it is compact, of a light gray to greenish color.



Silundum Furnace Elevation
Vertical Carbon plate Resistor



Silundum Furnace Plan
Horizontal Granular Resistor

ELEVATION AND PLAN OF SILUNDUM FURNACE.

It has a hardness apparently the same as carborundum and is heavy. This increase in weight over the carbon from which it is made is an indication of the more or less complete transformation of the carbon into silundum.

Its most valuable property and probable use is its ability to stand a high temperature in the air without sensibly undergoing oxidation, and as it is a conductor of electricity, its use as a resistor material.

Several experiments were made with a view to testing it in this capacity, and they pointed to a satisfactory material for temperatures up to, say, 1500° C. In one experiment a plate of silundum was placed on a graphite block and pressed on its upper surface by a vertical graphite electrode. By passing sufficient current through this system the silundum plate was raised to a high temperature and maintained so for three hours. The graphite block and electrode were oxidized to such an extent that there was very little left, while the silundum plate was not affected at all excepting the surface exposing the carbon from which it was made, which happened to be broken off. The carbon here was, of course, burned away leaving a box-like shell of silundum. The temperature was read at various times and was found to be 1200° C. and over.

The electrical resistance of the material varies greatly, depending upon the penetration, but there seems to be no reason why the material should not prove valuable as a resistor material and come into general use for a variety of purposes in which a high temperature is to be maintained electrically.

In the discussion which followed, Dr. Acheson remarked that silundum was nothing new; it was the same product which he had called silixicon. As to the real composition of silundum, Professor Tucker said that silicon vapors penetrated into the carbon; but as to the chemical composition he could give no information; it has many properties similar to carborundum. Its resistance is greater than that of carbon, but every piece of silundum seems to have its own resistivity. Mr. Tone stated that silundum consists principally of carborundum (96 per cent to 97 per cent) and silicon. Silundum, analyzed by Mr. Hansen, contained 80 per cent silicon, which is some 10 per cent more than is contained in carborundum.

Advances in Electrochemical Analysis.

Dr. EDGAR F. SMITH, of the University of Pennsylvania, delivered, by special invitation of the Board of Directors, a most interesting lecture summing up his work in the development of modern methods of electro-analysis. He explained that electro-analysis is only a small corner in the whole field of chemistry and that he had often tried to get away from it and undertake research in other directions, but that he was always attracted again by the fascination of electro-analysis.

He began working in this field some 30 years ago, when he first determined copper electrolytically on a suggestion of Wolcott Gibbs. In course of time he learned to determine other metals by electrolytic methods and to use electrolysis also for the separation of different metals, like copper and cadmium. At these early times, the criticism was often made that electro-analytic methods took too much time and were too expensive. These criticisms have been completely removed through the advances made in recent years.

Dr. Smith then showed some typical experiments with typical apparatus which he had brought over from his laboratory. One of the principal apparatus devised by him is the use of a rotating anode. This provides a good stirring of the electrolyte and thereby permits the use of a higher current density so that the analysis can be completed in a shorter time. Several experiments using the rotating anode were shown.

The second important piece of apparatus is the use of a mercury cathode for depositing metals. The amalgam formed is weighed and the metal deposited is thereby determined, while the solution is titrated for the anion, if it remains in the electrolyte (for instance, if a sulphate is analyzed with a platinum anode). It is, however, possible to catch the anion by using a special metallic anode. For instance, chlorides may be analyzed with a silver anode, the silver catching the chlorine. Other anions can be caught in the same way by the silver anode. For the determination of fluorides, calcium hydrate is put on the platinum gauze which forms the anode. An anode of this kind can be made up of a series of such layers of gauze in disk form.

A step further is represented by the use of a double compartment cell in which the mercury acts as a bipolar electrode. This is used for the analysis of sodium and potassium salts. Sodium chloride, for instance, is placed in one compartment, the chlorine being caught by the silver anode and the sodium by the mercury which acts as cathode in this compartment. The sodium amalgam formed is brought over to the second compartment of the cell which contains water resulting in the formation of sodium hydrate. The arrangement is quite analogous to the Castner Kellner cell. Many variations are, of course, possible. For the analysis of potassium sulphate the same double cell may be used with a platinum anode, yielding as before potassium hydrate in the outer compartment and sulphuric acid in the inner compartment.

A very interesting and useful separation is that of radium from barium. Of the various barium chlorides may be treated in

such a double-compartment cell. The radium comes out at the outside, free from barium and can be detected by its radio-active properties. The inner barium chloride solution is no longer radio-active.

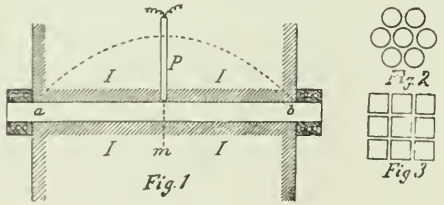
The lecture was listened to with the greatest interest, as Dr. Smith spoke in his most forceful style. He said he was not an electrochemist nor a physical chemist, but simply a chemist. He invited those who might be still doubtful about these methods to come to Philadelphia and see how they work in the hands of young unskilled students and how very uniform results are obtained in their hands.

After the lecture Professor Armstrong, of London, complimented Dr. Smith very highly. Dr. Smith might or might not be a physical chemist, but his lecture had shown him to be a very human person. It had emphasized the personal equation and explained Dr. Smith's great influence on his students.

Electrode Losses in Electric Furnaces.

In the Saturday morning session, four papers were read on this subject, the first paper being that of Mr. Carl Hering on the laws of the electrode losses in electric furnaces. The paper contains essentially the same theory which was given by Mr. Hering in his article in the October issue of this journal, although rearranged and amplified. The reader is, therefore, referred to this former article.

A second paper of Mr. Carl Hering describes a new method of measuring the mean thermal and electric conductivities of furnace electrodes. The object is to find by experiment these mean conductivities which should be inserted in his formulas



Figs. 1 to 3.—Measurement of conductivities.

in order to find the best ratio of length to cross-section of an electrode. The test is as follows, the arrangement being shown in Figs. 1 to 3:

Let *ab*, Fig. 1, be a rod of the electrode material to be tested, embedded in a heat-insulating material *I*, except at its ends, which are water-jacketed or otherwise cooled and kept at a constant known relatively low temperature. The refractory material *I* is assumed to be a perfect heat insulator. The cross-section of the rod is *S* square inches and the length of the embedded part is *L* inches.

Let a relatively large electric current be passed through this rod from end to end. This will raise the temperature of the embedded part, the highest being at the middle section *m*, and it will fall toward the two ends to the temperature of the water-cooled ends. A pyrometer *P* is introduced at the middle point.

When the constant current has been passed for a sufficient length of time, so that the stable state is reached, that is, until the pyrometer ceases to rise, then it is evident that all the heat generated in the rod electrically, flows out only at the two ends, as the heat insulation is assumed to be perfect. When this state has been reached, the temperature at the center and at the water-cooled ends, the current, and the voltage between the two terminals, should be measured. The product of the current and the voltage gives the heat flow in watts *W* which is leaving at the two terminals. It is not necessary to measure the heat absorbed by the cooling water, as this heat flow is determined much more readily and probably far more accurately by means of an ammeter and voltmeter.

The heat conductivity of this material is then determined from the following formula:

$$k = 0.02986 \frac{W L}{T S}$$

in which k is the mean heat conductivity in gram calories per second per square inch for one degree C. per inch, and T the difference in temperature in centigrade degrees between the maximum at the middle and that at the water-cooled ends.

From the same readings of the volts E and amperes C in this test the mean electrical resistivity for that same range of temperature is readily calculated from the formula

$$r = \frac{E S}{C L}$$

in which r is the resistivity in ohm, cubic inch units. This method is based on the assumption that the heat insulation of the test rod is perfect. This may be accomplished with probably no appreciable error by surrounding the test rod by a tube of the same or a similar material, which is electrically insulated from it, and which is also heated by a current to the same temperature at its middle part and cooled to the same temperature at the ends. The two heat gradients in the test rod and in the surrounding tube will then be the same, hence no heat will leave the embedded part of the test rod except the very slight amount which flows longitudinally through the cylindrical shell of heat-insulating (and therefore non-conducting) material surrounding the rod and escapes at its outer ends. If this shell is made very thin, just thick enough to insulate electrically, and the rod be made relatively large in cross-section, and long, the heat which is thus lost through this insulating material may be made extremely small, especially if the material is loosely fibrous or granular so that the actual heat insulation is practically due to the air in the interstices. Moreover, only one-half of this small heat loss comes from the test rod, the other half coming from the tube.

Instead of using a tube for obtaining this heat insulation, which may at times be difficult to do, it is much simpler and probably quite sufficiently accurate for all practical purposes, to surround the test rod with a number of similar rods embedded in the same insulating material and placed parallel and as near as possible to the test rod about as shown in Figs. 2 and 3 in which the middle one is the rod under test. The ends of each are water-jacketed like the test rod. These can then all be connected electrically in series with each other and with the test rod so that the same current heats them all; if then they are all of the same size and material, the temperature can be safely assumed to be practically the same in them as in the test rod, and it is then unnecessary to use a second pyrometer on the outer row of rods to see that the temperature is the same as that of the test rod.

* * *

A paper by Mr. C. A. Hansen, of the Research Laboratory of the General Electric Company, gave first an analysis of the electrode losses in one of his furnaces. This analysis is based on the formula that the electrode loss (the heat given off by the electrode from the cold end to the waterjacket) equals half the total Joulean heat loss plus the pure conduction loss due to temperature difference between the two ends. (See article of C. Hering in our October issue.) The furnace dealt with is shown in Fig. 4, the electrode design in Fig. 5.

The furnace has been so charged at different times that it would finish its run at 10,000 amp, 15,000 amp and 20,000 amp respectively, being kept at these current values for several consecutive hours in each case. The losses as determined in the cooling water under these conditions remain fairly constant, showing that in all probability an equilibrium has been established within the electrode. The temperature at the hot electrode end has been measured and for each case was found to be about 3200° C. The cold end of the electrode reached a temperature of approximately 200° C. The temperature difference was therefore 3000° C.

Mr. Hansen analyses the losses to see what can affect them and how far these losses are determinable from published data.

To determine the Joulean heat, or

$$C^2R = \frac{C^2\rho l}{S}$$

the current can be measured accurately enough for all practical purposes. Regarding the resistance of Acheson graphite, the only known figure is 0.00032 ohm per inch cube, given as the cold resistance by the Acheson Graphite Company. No

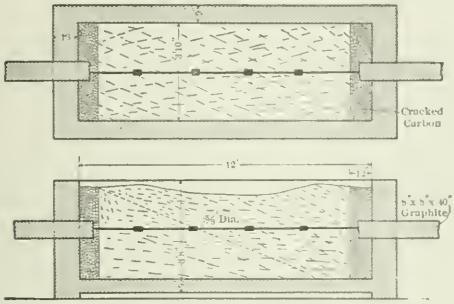


FIG. 4.—ELECTRIC FURNACE.

mention of a temperature coefficient is made. But what length of active electrode shall we use? The resistance of the terminal head is so much lower than that of the electrode within it that perhaps all of the current passes into the electrode at the extreme tip next the furnace. The electrode end within the furnace may disseminate the current in the charge all along its length. Obviously, all of the electrode length is not the resistor for the whole current carried.

As regards section, that is easier, for in all probability the carborundum packing, although it has been known to carry current (carborundum furnace), does not carry any large proportion of the current. "Skin effect" does not enter at 40 cycles, according to a numerical estimate of Mr. Hansen. This is due to the high specific resistance of the material.

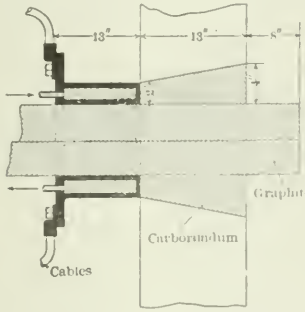


FIG. 5.—ELECTRODE DESIGN

Second, to find the heat conductivity from the formula

$$H = K\frac{(T_2 - T_1)\,S}{l}$$

it is stated that K is known for Ceylon graphite and a few other varieties, but not for Acheson graphite. $(T_2 - T_1)$ would be assumed anyway, if the calculation were to be made. In this particular case it is known closely enough. S and l are again open to the same speculation, as in the case of the C^2R loss.

Third, contact resistance is neglected altogether in the formulae so for published.

When the current does not exceed 10,000 amp in the electrode shown in Fig. 5 the end wall remains intact. If we assume in that case that the electrode is maintained at an average temperature of 1,200° C., is surrounded by a silica brick wall 10 in. thick, the outside of which is kept at room temperature, the loss of heat through the wall would only be 3.5 kw, and half of this only would, strictly speaking, be an electrode loss. This is, of course, only a very rough approximation.

When the current is increased to 20,000 amp in the same electrode, a volume of silica brick, weighing some 100 lb. to 125 lb., disappears during each run. In fact, it is almost possible to correctly guess the ammeter reading by watching the furnace fumes. Now to vaporize 100 lb. to 125 lb. of silica requires energy which would otherwise appear in the cooling water, but the silica passes up through the furnace charge and must naturally lose some of that energy as it passes through the cold top layer.

One kw-hour per pound of SiO_2 vaporized may be hazarded as a guess at the energy quantity thus removed, one-half of which should properly be added to the cooling water readings.

As it is evident that in the first place knowledge of the conductivities or resistivities of electrode materials is all important, Mr. Hansen gives the following figures for resistances of graphite and carbon electrodes:

Resistance of Acheson Graphite Electrodes

Size of Section	Sample Taken.	Number of Samples.	Ohms per inch Cube.
⅛ inch diameter	Lengthwise	3	0.000391 -0.000396
¼ inch "	"	3	0.000343 -0.000379
⅜ inch "	"	3	0.000349 -0.000353
½ inch "	"	3	0.000268 -0.000290
1 inch "	"	2	0.000885 -0.000898
2 inch "	"	2	0.000363 -0.000367
3 inch "	"	2	0.000425 -0.000433
3 inch "	Crosswise	2	0.001025 -0.001030
4 inch x 4 inch	Lengthwise	2	0.000378 -0.000399
4 inch x 4 inch	Crosswise	2	0.000802 -0.000802
6 inch diameter	Lengthwise	2	0.000329 -0.000314
6 inch "	Crosswise	2	0.000655 -0.000662

The figures given are the extremes of 12 measurements made on each sample at about 25° C. The samples were cut from material taken from stock of the General Electric Company in April, 1909.

As regards the temperature coefficient, measurements were made on a ⅛-in. diameter rod in vacuo, with the following results, which the author believes represent the true resistance at a temperature not over 50° C. from that given:

Temperature, ° C.	Resistance, %
25	100
400	91
800	85
1,200	66.0
1,600	65
2,000	65
2,200	69.0

Mr. Hansen also places on record some measurements on National carbon electrodes taken from stock of the General Electric Company at various times within the last three years.

Resistance of National Carbon Company Electrodes

Size of Section.	Sample Taken.	Number of Samples.	Ohms per inch Cube
¼ inch diameter	Lengthwise	5	0.00113
½ inch "	"	5	0.00047
1 inch "	"	19	0.00132 -0.00193
4 inch x 4 inch	"	1	0.00185
4 inch x 4 inch	Crosswise	2	0.00225 -0.00254
6 inch x 6 inch	Lengthwise	1	0.00137
6 inch x 6 inch	Crosswise	2	0.00170 -0.00170
8 inch x 8 inch	Lengthwise	2	0.00131 -0.00180
18 inch x 18 inch	"	3	0.00116 -0.00100

In justice to the National Carbon Company, it is to be stated that the 18 in. x 18-in. x 72 in. carbons, last referred to, were made over three years ago, and at the time they were the largest ever made in this country. It is understood that large electrodes recently made are very much better, and in that case the resistance should be found to be very much lower than the values given.

The author has also speculated as to the probable effect of temperature on the resistance of carbon, with curious results.

Samples of ⅝-in. diameter carbon rods obtained from the National Carbon Company were fired in groups of three at various temperatures in an Arsem vacuum furnace. One batch of four samples was fired in an electric tube furnace to 3500° C. Average cold resistance values, etc., for the fired samples are given:

Temperature C°	Loss in Weight. Per cent	Linear Shrinkage. Per cent.	Cold Resistance of Fired Samples. Per cent. Original Cold Resistance.
1200	0.15	0.53	91.6
1600	0.56	0.40	87.0
2000	1.29	1.19	77.6
2400	1.64	2.38	65.9
2800	1.93	0.52	50.9
3500	2.43	0.117	22.4

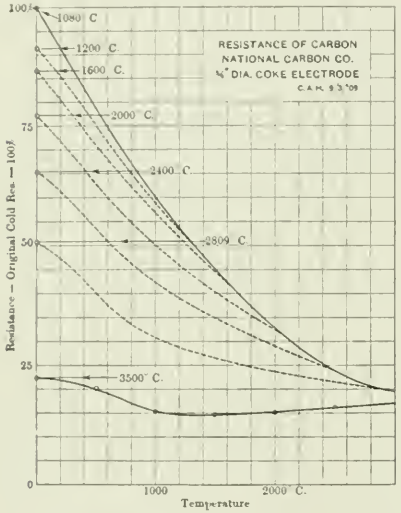


FIG. 6.—VARIATION OF RESISTANCE OF CARBON ELECTRODE.

The resistance of the 3500° samples, i.e., 0.000307 ohms per inch cube, is practically the same as that given for graphite.

Fig. 6 shows where the speculation as to the temperature resistance diagram for carbon comes in. If we attempt to measure the temperature coefficient of resistance and, in the course of our measurements go to a temperature higher than that at which the carbon was originally fired, the curve will not return upon itself on cooling down. For instance, if we go to 1200° C. and cool off, the curve will return not to 100 per cent, but to 91.6 per cent; if cooled down from 1600° it will return to 87 per cent, etc., until finally, if fired to 3500° C., it will return upon the curve for graphite, since the amorphous carbon is no longer amorphous carbon, but graphite.

There is no reason to suppose that, when we exceed the maximum temperature to which the carbon has previously been fired, there is a break in the resistance curve. The curve for any carbon will be a smooth one, hence the dotted curves are all drawn tangent to the parent curve. For all of the commercial carbons, the temperature coefficient of which the author has measured, the 1200° hot resistance is around 60 per cent of the cold resistance. Upon the assumption that the 1200° resistance is about 60 per cent of the cold resistance for National Carbon Company electrode material fired to various temperatures and upon the assumption that all of the branch curves are tangent to a common curve, the extreme ends of which are located, the curves shown are a reasonable derivation.

If, now, we assume a straight line gradient in our electrode and a temperature difference between hot and cold ends, as in the case under consideration, of 3000° C., the effective resistance of our graphite electrode will be the true average resistance of graphite as determined by averaging a lot of resistance ordinates equally spaced along the temperature axis of the temperature-resistance diagram for graphite. So, for graphite, this is fairly simple when we have the "constants." For $T_2 - T_1 = 3200° - 200°$ C., the average is about 78 per cent of the cold resistance.

With carbon, on the other hand, if the electrode has been alternately heated and cooled several times, different points in its length being heated to different temperatures, the working resistance of the electrode may be anything at all. Any point within the triangular area of Fig. 6 will be sure to fit out some point in the electrode with its proper "constant." Let as assume, however, that, as for graphite, the average ordinate along the parent curve holds. For our furnace and carbon electrodes, the effective resistance is then 40 per cent of the original cold resistance, or, for 4-in. x 4-in. x 40-in. electrodes, 0.00072 ohms per inch cube.

Electrode resistance was actually measured under the operating conditions. The results will be taken up later.

Effective Length of Electrode and Contact Resistance.

These are treated together by Mr. Hansen, for they are to a certain extent interdependent.

The length of our electrode may be divided into three portions and the portions treated separately. These portions are:

1. The length within the furnace itself.
2. The length embedded in the furnace wall.
3. The length within the brass terminal.

1. Inspection of the experimentally determined temperature gradient for a carbon electrode similar mechanically to the one under consideration[1] leads to the conclusion that practically all of the current is carried to the extreme electrode tip, making this entire length an effective length.

2. It is safe to assume that practically all of the current is carried by the electrode portion embedded in the furnace wall, making this entire length an effective length.

3. With the length within the brass terminal, which is over 38 per cent of our entire length, contact resistance enters to affect the effective length of conductor.

The author considers the terminal and electrode multiple conductors from cable contact to the terminal tip next the furnace wall, and that the contact between the two is equally divided between the two ends of the terminal. See Fig. 7.

B = resistance of brass terminal.
G = resistance of graphite electrode.
$C = C^1$ = contact resistance.

The ratio of the current carried via BC^1 to that carried via CG becomes $C + G$ to $B + C$.

G, taking 0.000350 ohm per inch cube = 0.000071 ohm.

B, taking brass at 0.0000032 ohm per inch cube = 5 times resistance of copper = 0.0000013 ohm.

If we neglect contact resistance, we find that 98.2 per cent of the current goes via BC^1, as against 1.2 per cent via CG. In other words, the current will be crowded into the electrode at the terminal end next the furnace wall, making very little of the length within the terminal an effective length. If the contact resistance is great as compared with G and B, then the current will be evenly distributed throughout the contact area, making one-half the length in the terminal effective conductor for the whole current, but in that case contact resistance must inevitably be a factor for consideration in calculating the electrode losses.

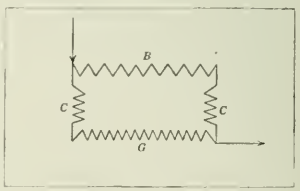


FIG. 7.—CURRENT THROUGH TERMINAL.

[1] Trans. Am. Electrochem., 15, 292.

Some time ago the author built a furnace with the resistor made up of carbon motor brushes, each 2 in. x 2 in. x 7/16 in., with a resistivity in inch ohm units of 0.00120. These brushes were piled flatwise in a vertical column and were in good mechanical contact with one another. Pressure was applied to the column by means of a screw, but the pressure was not measured. Mr. Hansen judges it to be in excess of 200 lb., or over 50 lb. per square inch of contact.

The cold column had a contact resistance over 100 times the resistance of the brushes themselves, figured as a solid carbon column. At 1800° the contact resistance was at least 20 times the resistance of the carbon.

This indicated that it would be worth while to look into the contact resistance question a little more closely.

Accordingly, an attempt was made to actually measure the contact resistance of the furnace terminals under operating conditions. It would perhaps have been simpler to measure the contact resistance of a column of plates, alternating graphite with brass, and it was intended to do this in case the projected experiment did not yield results.

It is no easy or extremely accurate matter to determine the resistance of a conductor carrying 15,000 amp or 20,000 amp alternating current by means of a voltmeter, and the results obtained are intended merely to give the approximate magnitude of the loss.

A 1¼-in. diameter graphite rod was threaded vertically into the tip of electrode within the furnace, and this rod projected some 4 in. above the charge. A terminal was threaded to the end of the graphite rod, another into the cold end of the electrode, and a third connection was made to the brass terminal. The voltmeter leads were twisted together and brought out to the voltmeter, which, of course, was protected as much as possible from stray fields. The only loop in the voltmeter circuit was the rectangle bounded by electrode graphite rod, voltmeter lead and furnace wall, 34 in. x 26 in. in dimension.

The results obtained were as follows: E being the potential drop:

Run of September 8, 1909. (Graphite electrode as in Fig. 5.)

Time.	Current.	Terminal to Hot Electrode End. E.	Kw.	R. Ohms.	Tip to Tip of Electrode. E.	Kw.	R. Ohms.	Contact. E.	Kw.	R. Ohms.	Water. Kw.
8:30	Start										
9:30	3840	2.3	8.80	0.00060	1.6	3.84	0.00026	1.3	4.96	0.00034	2.4
10:00	4080	2.3	9.40	0.00056	1.0	4.08	0.00024	1.3	5.32	0.00032	2.6
10:30	6000	2.8	16.80	0.00047	1.0	6.00	0.00017	1.8	10.80	0.00030	4.5
11:00	6480	2.8	18.15	0.00043	1.1	7.13	0.00017	1.7	11.02	0.00026	5.2
11:30	9600	3.2	30.70	0.00033	1.2	11.51	0.00013	2.0	19.19	0.00020	12.0
12:00	10500	3.2	33.60	0.00030	1.3	13.65	0.00012	1.9	19.95	0.00018	14.0
12:40	12700	3.2	40.70	0.00025	1.8	22.85	0.00014	1.4	17.85	0.00011	20.5
1:10	13200	3.1	40.90	0.00023	2.0	26.40	0.00016	1.1	14.50	0.00007	21.0
1:45	14900	3.4	50.70	0.00023	2.2	32.80	0.00015	1.2	17.90	0.00008	29.9
4:15	16080	3.4	54.7	0.00021	2.2	35.40	0.00014	1.2	19.30	0.00007	37.5
4:45	16800	3.6	62.0	0.00021	2.3	38.60	0.00014	1.3	21.80	0.00007	36.8
5:10	17280										

Cut off power, 3272 kw-hours in furnace.

Actual water record was taken to correspond only with the three last readings. The other water losses are taken from previous runs: they all check to within a few per cent when compared on the basis of current if the power curves are at all comparable, and, as a rule, they are comparable. The terminal was in excellent shape mechanically—good contacts—drawn up as tightly as four standard ¾-in. bolts would safely stand without stripping threads.

The resistance data is plotted in Fig. 8

Contact resistance is certainly a factor worth considering. To get back, then, to Fig. 4:

$$B + C = 0.0000013 + (2 \times 0.00007) = 0.0001413 \text{ ohm.}$$

$$C + G = (2 \times 0.00007) + 0.000071 = 0.000211 \text{ ohm.}$$

Current carried via $BC = 60$ per cent as against 40 per cent via CG. The resistance of the multiple circuit is 0.0000845 ohm, which leaves only 0.0000145 ohm for the graphite electrode. In other words, only 20.4 per cent of this portion of our electrode is effective conductor for all of the current. It would also be added that decreasing the contact resistance or increasing the resistance of the electrode itself diminishes this effective length percentage.

For the purpose of this paper, however, the author thinks we are justified in making the 20 per cent value above developed a general value.

Also contact resistance, which has so far been neglected in all formulas for the calculation of electrode losses, must somehow be brought into those formulas. Its value is dependent upon current density at least, and as well upon temperature of contact, nature of contact, whether oxidized or not, etc., but for our own purpose, since all but current density is fairly constant, the values per square inch for it may be obtained by

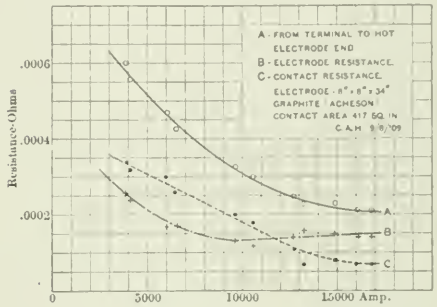


FIG. 8.—RESISTANCE DATA.

multiplying the resistances given in curve form (Fig. 8) by 417—the contact area in square inches.

It is also curious to compare the contact losses here measured with some which the author proposed last May as perhaps giving the magnitude of this loss.

"*Contact Resistance Between Waterjacket and Electrode.*

"Based on brush to commutator resistance at 2 lb. per square inch pressure, equivalent to 832 lb. distributed pressure on an 8-in. x 8-in. electrode in a 13-in. waterjacket.

1. 10,000 amps in terminal = 24 amps per square inch contact.
   $^2r = 0.036\ R = 0.0000865\ C^2R = 8.65$ kw.
2. 15,000 amp in terminal = 36 amp per square inch contact.
   $r = 0.026\ R = 0.0000625\ C^2R = 14.05$ kw
3. 20,000 amps in terminal = 48 amp per square inch contact.
   $r = 0.023\ R = 0.0000553\ C^2R = 22.12$ kw.

Comparing these results with the data determined, we have:

Current.	R.	C^2R.	R.	C^2R	
10,000	0.000 865	8.65	0.0018	19.95	
15,000	0.000 0625	14.05	0.0007	19.30	
20,000	0.0000553	22.12	.00006	24.00	(exterpolated value)

We can now also arrive at fair valuations of both electrical resistivity and heat conductivity

Electrical Resistivity of Graphite[1]

Electrode composed of four pieces 4 in. x 4 in. x 40 in. bundled together.

The resistance of an average Acheson graphite electrode used with a temperature range $T_2 - T_1 = 3200 - 200°$ C., by actual measurement is then 0.00037 ohm per inch cube

By cold resistance and temperature-resistance diagram, the

[2] r = resistance per square inch of contact.
[1] Same as detailed above.

same electrode should have a resistivity of 0.00030 when the lengthwise resistance figure is taken.

Time.	Current.	Resistance.	Resistivity (Ohms per inch Cube).
9:30	3840	0.00026	0.00070
10:00	4080	0.00024	0.00064
10:30	6000	0.00017	0.00045
11:00	6480	0.00017	0.00045
11:30	9600	0.00013	0.00035
12:00	10500	0.00012	0.00034
12:40	12700	0.00014	0.00037
1:10	13200	0.00016	0.00043
2:45	14900	0.00015	0.00041
4:15	16080	0.00014	0.00037
4:45	16800	0.00014	0.00037

Mr. Hansen prefers to favor the lower value of resistivity and to adopt the value of 0.00032 ohm per inch cube as the working value for these extreme limits of temperature variation.

Heat Conductivity.

From the experimental data obtained by measuring the cooling water losses of carbon and graphite electrodes not carrying current, as previously described, it is also possible to assign conductivity figures to both carbon and graphite.

Graphite "idler":

$l = 12.75$ in. $\quad T_2 = 2830°$ C.
$S = 16.0$ $\quad T_1 = 30°$ C.

Loss = 3580 watts.

K for graphite = 1.65 watt seconds/sec./° C./ for 1 in. length and 1 sq in. section.

= 0.162 (c.g.s. units.)

Carbon "idler":

$l = 12.75$ in. $\quad T_2 = 3500°$ C.
$S = 16.0$ $\quad T_1 = 30°$ C.

Loss = 445 watts.

K for carbon = 0.165 watt seconds/sec./° C./ for 1 in. length and 1 sq. in. section.

= 0.0162 (c.g.s. units.)

In connection with this last experiment, Mr. Hansen replies to Mr. Hering's criticism of it (this journal, Vol. VII, page 400): "Comparing different materials experimentally by means of electrodes of the same size is equally incorrect and misleading; it also leads one away from the goal, rather than toward it."

Mr. Hansen's reply is: "I fail to see how the comparison would be improved by resorting to electrodes of different sizes. Grant that we did not have enough of an idea of 'constants' involved to calculate a loss directly. Would we then gain by gratuitously making the conditions such that no single factor would be the same for the two materials to be compared? In either case, whether the electrodes are of the same size or of different sizes, a set of conditions is experimentally determined. Without resorting to doubtful 'constants' and doubtful dimensions, a comparison of some kind may be made if the electrodes are of the same size, whereas without resorting to 'constants,' of which even the approximate magnitude was unknown, no comparison whatever is possible, if the electrodes are of unlike sizes. Again, in these experiments both electrodes—carbon and graphite—were run at current densities, which cannot be practically maintained even in the graphite electrodes, densities which were then extraordinarily high for carbon. The attempt was made to cover the entire practicable range of both electrodes, and comparisons at different current densities for the two electrodes can be made with greater security by interpolating the data obtained on like sizes than would be possible in the other case."

We have now the most important data for calculating losses.

The electric resistivity of graphite under conditions applicable to a temperature difference of 3000° C. is 0.00032 ohm per inch cube = 0.000812 ohm per centimeter cube. The electric resistivity of carbon under the same conditions may be taken as 0.00072 ohm per inch cube, or 0.00183 ohm per centimeter cube. Ratio of carbon resistance to graphite resistance under these conditions is 2.25.

The heat conductivity of graphite 3200° C. to 200° = 1.65 watt-second per second per degree Centigrade for 1 in. length and 1 sq. in. section = 0.162 c.g.s. units. The heat conductivity of carbon under the same conditions is 0.165 watt-seconds per second per degree Centigrade for 1 in. length and 1 sq. in. section = 0.0162 c.g.s. units.

Contact resistance may be taken as 0.075, 0.029 and 0.025 ohm per square inch for brass to graphite at current densities through the contact area of 24 amp, 36 amp and 48 amp per square inch, respectively.

Calculation of Losses for Titanium Carbide Furnace Electrodes

Material, graphite.
$T_2 - T_1 = 3000°$ C.
Section = 64 sq in.
Length = 27¾ in.
Current = 10,000 amp, 15,000 amp, 20,000 amp.
Heat loss is the same in each case.

$$H = K\,\frac{(T_2 - T_1)\,S}{l} = \frac{1.3 \times 3000 \times 64}{23.75} = 10.55 \text{ kw}$$

$$C^2R \text{ loss} = \frac{C^2\rho l}{S} = C^2 \times \frac{0.00032 \times 27.75}{64} = C^2 \times 0.00011.$$

$C = 10{,}000 \quad C^2R = 11.8$ kw., $\quad C^2R/2 = 5.9$ kw.
$C = 15{,}000 \quad C^2R = 26.6$ kw., $\quad C^2R/2 = 13.3$ kw.
$C = 20{,}000 \quad C^2R = 47.2$ kw., $\quad C^2R/2 = 23.6$ kw.

Total loss = $H + C^2R/2$ (no account taken of contact resistance).

According to this formula, then, the losses for 10,000 amp, 15,000 amp and 20,000 amp will be 16.45 kw, 23.85 kw and 34.15 kw, respectively.

The contact resistance losses are 19.95 kw, 19.30 kw and 24.00 kw, respectively, for 10,000 amp, 15,000 amp and 20,000 amp.

If we add all of this to the losses previously calculated we get, respectively, 36.40 kw, 43.15 kw and 58.15 kw.

If we add half of it only, we get, respectively, 26.42 kw, 33.50 kw and 46.15 kw.

The corresponding losses actually measured by cooling water methods are 22 kw, 28 kw and 36 kw.

The losses as calculated from the curve sheets given in a previous paper[4] are 21.2 — 34.4, if we for once exterpolate the curve sheets given, 42 kw, respectively.

Putting these results together in table form we get:

Current.	A	B	C	D	E
10,000.....	16.45	36.40	26.42	22.00	21.2
15,000.....	23.85	43.15	33.50	28.00	34.4
20,000.....	34.15	58.15	46.15	36.00	42.00

A Loss = $\frac{C^2R}{2} + H$

B Loss = $\frac{C^2R}{2} + H +$ Contact C^2R

C Loss = $\frac{C^2R}{2} + H + \frac{\text{Contact } C^2R}{2}$

D Loss = Measured in cooling water.
E Loss = Curves based on measured losses for 4-in. x 4-in. graphite electrodes.

The discrepancy between D and E at 15,000 amp and 20,000 amp is, the author believes, in part, a measure of the losses from electrode to furnace wall. The major part of the wall loss is, however, no doubt, due to volatilization of silica, which makes the actually measured losses low.

As a conclusion, then, Mr. Hansen thinks that either column C or E (i.e., either the losses calculated from loss =

$$\frac{\Sigma\, C^2R}{2} + H,$$

or the losses as calculated from the curve sheets given)[5] more nearly approximate the true losses than either the losses ac-

[4] Electrochem. and Met. Ind., 7, 358.
[5] Electrochem. and Met. Ind., 7, 358.

tually measured in cooling water *at high-current densities*, or those calculated from heretofore published formulas.

Fortunately, we can considerably improve upon our contacts by increasing the number of electrodes which make up a given section, and then making use of the increased surface afforded by these separate electrodes, as, for instance, by providing individual threaded caps.

Since in this case the contact area is not necessarily a function of the dimensions of the entire composite electrode, the equation $\frac{1}{2} C^2R + H = \text{Loss}$, where C^2R refers only to the actual electrode resistance, should be of value in calculations for the minimum-loss-electrode dimensions.

Mr. Hansen then criticizes the statement of Mr. Hering that the design of electrodes should not be based on figures of current density. Mr. Hansen prefers to combine the best ratio of l to S found from electrode losses, with the permissible current density, as follows:

He prefers, in connection with his own work, to take a current density of 150 amp per square inch for graphite, and 50 amp per square inch for carbon electrodes, since he knows from experience that when he exceeds these densities for any considerable period, his end wall is badly corroded. On this basis and solving Mr. Hering's equation for dimensions for a 20,000-amp electrode, he finds a ratio of length to cross-section = 0.278 if inch-units are used.

At a current density of 150 amp per square inch, the graphite electrode would have a section of 133 sq. in. and an effective length of 37.0 in.

Calculating the dimensions of a carbon electrode to do the same work, he found that with the "constants" here given l/S should be 0.0585. At 50 amp per square inch, this means an electrode 20 in. x 20 in. in section and 23.4 in. effective length.

The minimum loss for the graphite electrode would be 34.4 kw if we can assume that contact loss can be reduced to zero or nearly zero. The minimum for the carbon electrode would be 16.9 kw.

The ratio of minimum losses is 2.04 in favor of carbon

It is also evident that the equation

$$\frac{l}{S} = \frac{1}{C}\sqrt{\frac{2\,(T_2 - T_1)}{\rho}\,k}$$

(which is the same equation as Mr. Hering's, except that here the heat conductivity k is measured in watt-seconds) may be converted into

$$l = \frac{1}{d}\sqrt{\frac{2\,(T_2 - T_1)}{\rho}\,k}$$

where d = current density.

If we assume that 50 amp for carbon and 150 amp for graphite are good current densities for general work, and that the "constant" K and ρ hold for most work, we can solve for length directly

$$l = \frac{1}{150} \times \sqrt{\frac{2\,(T_2 - T_1)}{\rho}\,k} = 0.00\sqrt{(T_2 - T_1)}$$

for graphite and

$$l = \frac{1}{50} \times \sqrt{\frac{2\,(T_2 - T_1)}{\rho}\,k} = 0.43\sqrt{(T_2 - T_1)}$$

for carbon. l is expressed in inches, $(T_2 - T_1)$ in deg. C.

In furnaces of the Héroult type, operating conditions require current densities in the electrodes of 30 amp or less per square inch, but in no other case that Mr. Hansen recalls would these equations have so little bearing in determining the electrode dimensions as in the present types of steel furnaces. Protection for the exposed terminals and a maximum uninterrupted downward feed are the determining factors in this work, aside from the choice of an electrode section which is great, relative to the area of the bath surface.

* * *

The fourth paper on the subject of electrode losses in electric furnaces was presented by Dr. F. F. Roeber. In the introduction of this paper it is shown that the formulas as developed by Mr. Hering are based on the assumption of constant thermal and electric conductivities. Since this is an assumption which is not realized in practice it is important to investigate how much of the basic principles of the theory will hold good for more general conditions.

The problem is attacked in two different ways. The first way starts, like the classical mathematical theory of heat and like Mr. Hering's theory, from the investigation of an infinitely small particle. It is investigated what happens there and the fundamental differential equation is established. This is then integrated first under the assumption that both the thermal and the electric conductivities are linear functions of the temperature.

The investigation is restricted to the practically important case in which no heat passes in either direction through the hot end of the electrode, since this is the condition under which electrodes are preferably operated and which should form the basis of electrode design. In this case the hot electrode end is at exactly the same temperature as the furnace charge next to it.

A somewhat complicated formula is found giving the ratio of length to cross-section which an electrode must have in order to fulfill this condition, if the temperature T_0 at the hot end and the temperature T_1 at the cold end are given, if the current i is given and if the two conductivities are known linear functions of the temperature.

Three special cases of this solution are those in which either the electric conductivity or the heat conductivity or both conductivities are independent of the temperature. If both conductivities are independent of the temperature a formula identical with that of Mr. Hering is obtained. Also if the electric conductivity alone is constant and independent of the temperature while the thermal conductivity is a linear function of the temperature, it is proven that the formula for constant conductivities is correct, if in it the arithmetic mean value of the thermal conductivity between the two given temperatures is inserted.

The theory is then extended to the most general case in which the two conductivities are assumed to be distinct functions of the temperature, but nothing whatever is assumed concerning the nature of the functions.

For this most general case the following fundamental principle is proven: If no heat passes in either direction through the hot electrode end within the furnace, while the current i passes through the electrode, the ratio of length to cross-section equals the reciprocal value of the current i, multiplied by a value which depends only on the electrode material and the two temperatures T_0 and T_1 at the two ends of the electrode. The only two assumptions made are the condition of stationary operation (the temperature being independent of the time) and the condition that no heat is given off by the electrode sideways to the refractory walls.

In the second part of the paper the electrode is considered at once as a whole, so that the investigation is not based on differential calculus. The assumptions are made that the condition of operation is stationary (the temperature at any point remaining constant in time) and that no heat is given off from the electrode to the surrounding walls.

Under these conditions, the heat A (positive or negative) flowing from the furnace inside through the hot electrode end into the electrode, and the heat B (always positive) flowing from the electrode through the cold end to the outside (for instance, to the water jacket) have definite values, which depend on the special conditions under which the stationary operation of the furnace takes place.

It is then always possible to write A and B as the difference and sum respectively of two other values x and y

$$A = x - y$$
$$B = x + y$$

This involves, of course no assumption at all. It is so far simply a way with mathematical symbols. But it is easy to see that x and y have a distinct physical meaning.

By subtracting A from B, we get,

$$y = \frac{B - A}{2}$$

$B - A$ is the difference of the heat which flows out of the electrode at the cold end and the heat which flows into the electrode at the hot end. Since according to the assumption no heat flows through the side walls of the electrode, $B - A$ must be the total Joulean heat generated within the electrode. Hence y = one-half the total Joulean heat.

Further, it is evident that $x = \frac{A + B}{2}$ = half the sum of the two heats flowing into the electrode at the hot end and out of the electrode at the cold end (both measured in the same direction).

Hence we have a superposition of two phenomena: First, a flow of the same heat $x = \frac{A + B}{2}$ through the two ends in the same direction, and second, a generation of Joulean heat $2y$ within the electrode from electrical energy, this heat flowing off impartially one-half $(+y)$ to one side and one-half $(-y)$ to the other side.

So far everything is very simple. But the trouble is that in the general case we cannot consider the two phenomena independently of each other. The heat x is not "the heat which would flow if there were no current." Both the temperature drop from the hot inside to the cold outside and the generation of Joulean heat are responsible for the temperature gradient within the electrode. Hence the Joulean heat affects the temperature and therefore the heat conductivity at any point so that the heat flow x is not the same as though no current were flowing, because in the latter case the temperature and the heat conductivity at any point would have different values from our case.

In quite the same way the Joulean heat $2y$ is not the same as though there was no temperature drop from the hot to the cold end, because the latter affects the temperature gradient and therefore the electric conductivity at any point and therefore the Joulean heat.

Hence the two phenomena of simple heat conduction x and Joulean heat production $2y$ are not independent of each other in general.

But whatever the function which determines the dependence of the conductivities on temperature, the condition under which no heat passes through the hot electrode end in either direction, is given by the equation $x = y$. Or in words, the heat conduction due to the temperature difference at the two ends must equal half the Joulean heat. Since the two terms cannot be calculated independently in general, it is preferable to stop here with the analysis and to rely upon the experiment for further developments.

The author proposes to use Mr. Hering's method of measurement (see abstract above, Figs. 1, 2 and 3), but not to determine the mean values of the two conductivities, but directly the best ratio of length to cross-section.

This can be done in the following manner, which is free from any theoretical objection, since it is based on the general rule proven before in the paper, that whatever may be the functions which determine the two conductivities in their relation to the temperature, it is generally true that the product of the current i and the ratio of length l to cross-section s depends only on the two temperatures T_0 and T_1 at the two ends and on the electrode material, if no heat shall flow through the hot electrode end in either direction. This rule may be stated also in this way: Whatever may be the functions which determine the two conductivities in their relation to temperature, it is generally true that the product of the length of electrode and current density depends only on the two temperatures T_0 and T_1 at the two ends and on the electrode material, if no heat shall flow through the hot electrode end in either direction.

The latter assumption is fulfilled for the arrangement shown in Fig. 1 in Mr. Hering's paper for either half of the electrode from the center to one of the two ends. The temperature at the center is a maximum $= T_0$. The temperature T_1 at the ends is maintained constant by water cooling or some other arrangement. Then it is possible to find the characteristic curve giving $l\,i/s$ as function of the temperature T_0.

Assume that we make a test with graphite. We will use a rod $a\,b$ of length $2l$ and cross-section s. We keep the temperature T_1 at the two ends a and b constant, for instance, by water cooling, and we measure the temperature T_0 at the center and the current i. Then according to the theory $\frac{l}{s}\,i$ must depend solely on T_0.

By raising the curent i from zero upward and waiting till equilibrium is established, every increase of current i will produce a rise of temperature T_0. We can then prepare a table or plot a diagram with the temperature T_0 as abscissas (T_0 always greater than T_1) and the value $\frac{l}{s}\,i$ as ordinates.

The theory states that if we repeat the same experiment with another rod of length $2l'$ and another cross-section s' and if the current which produces the maximum temperature T_0 at the center is now i', the value $\frac{l'}{s'}\,i'$ for any temperature T_0 must be the same as in the preceding set of experiments. This would be the most direct and crucial test of the correctness of the theory and of the proper execution of the measurement.

When this is done, the diagram we have plotted will directly answer the question of the best ratio of length of cross-section to be selected for any graphite electrode with water-cooled end (temperature T_1), if the temperature T_0 of the furnace and the current i are specified. We would simply find from the curve in the diagram the value $\frac{l}{s}\,i$ which corresponds to the given temperature T_0 and by dividing the value $\frac{l}{s}\,i$ by the given current i, we find the best ratio of l to s.

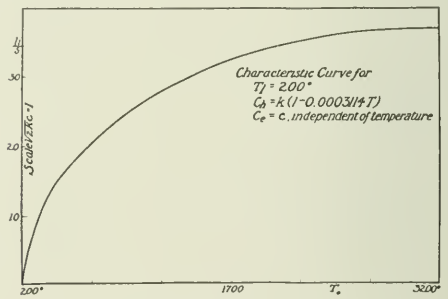


FIG. 9.—RELATION BETWEEN $l_{i/s}$ AND T_0.

Of course, the diagram will answer likewise the question what current i would have to be employed with an electrode of given length l and cross-section s in order to use it under best conditions (so that no heat flows in either direction through the hot end) for a given temperature T_0 at the hot end.

Any characteristic curve of this kind holds good only for the same material and for the same temperature T_1 of the cold end. For any other material and for any other temperature T_1 of the cold end, other characteristic curves must be plotted. To give a rough idea of the general character of such a curve, Fig. 9 gives the theoretical curve for an electrode material which (like graphite, according to Mr. Hansen) has, at 200° a thermal conductivity 270 times that at 3200°. But the heat conductivity c_h is assumed to be a linear function of temperature, and the electric conductivity c_e to be independent of temperature. The cold end of the electrode is maintained at a constant conductivity of 200°.

There was quite an extended discussion of the subject of electrode losses, participated in by Messrs. Hansen, Hering, Richards, Grower, Lidbury, and Arsem, while a communicated discussion of Dr. Kennelly gave a graphical representation of the laws of electrode losses in form of a diagram.

Explosive Antimony.

A paper by Dr. R. C. PALMER on "a new electrolytic method for the preparation of explosive antimony" was presented, in the author's absence, in abstract by the Secretary. The paper gave a history of the production of explosive antimony and then described experiments of the author on the electrolysis of non-aqueous solutions of antimony trichloride. Acetone is a suitable solvent. The best conditions for carrying out the electrolysis were established. The deposit has the characteristic flaky deposit.

Perchloric Acid.

A paper by Mr. FRANK C. MATHERS on a method of producing perchloric acid was presented, in the author's absence, in abstract by the Secretary. The perchloric acid is produced from sodium perchlorate by treating with an excess of hydrochloric acid. The paper was only of a preliminary nature, as the author proposes the use of perchlorate baths for electroplating.

Practical Conductance of Electrolytes.

A paper on this subject by Profs. JOSEPH W. RICHARDS and WALTER S. LANDIS was presented by Dr. Richards. The paper discusses the actual conductance of the electrolyte in electrolytic refining tanks as the same are ordinarily set up and operated.

In almost all refining tanks the edges of the anode and cathode plates are at some distance from the sides and bottom of the tanks. The free space, that not directly included between the plates, is a field through which stray current flows, the current lines being usually curved. It adds considerably to the conductance of the electrolyte. The authors have measured experimentally the conductance of these lateral or bottom prisms

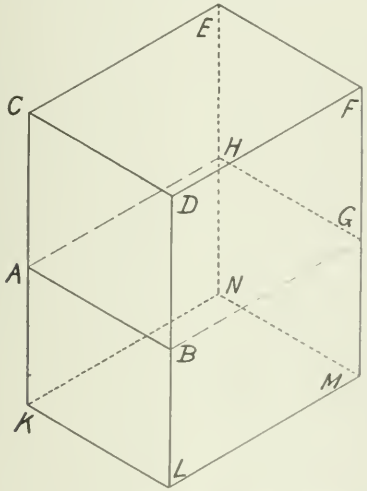


FIG. 1.—ARRANGEMENT OF EXPERIMENTS.

of electrolyte in order to see to what extent they influence the conductivity of the electrolyte as a whole.

The method used was to place two electrodes *ABCD* and *EFGH* (Fig. 1) of pure copper in a neutral copper sulphate solution against the ends of a glass cell, which they completely covered (in the figure they are shown raised from the bottom). Readings of current and voltage allowed the calculation of the conductance (equal to the ratio of current to voltage) of the cell as a whole. The plates were then raised by intervals of 1 cm and the conductance of the cell determined each time as before. From the conductance of the cell as a whole as thus measured at each interval of rise was subtracted the conductance of the prism of electrolyte *ABCDHEFGH* directly between the plates leaving the conductance of the bottom prism *ABKLMNGH*. The conductance of the bottom prism was then compared with its full conductance, i.e., that measured between opposite parallel plates and the percentage which the former

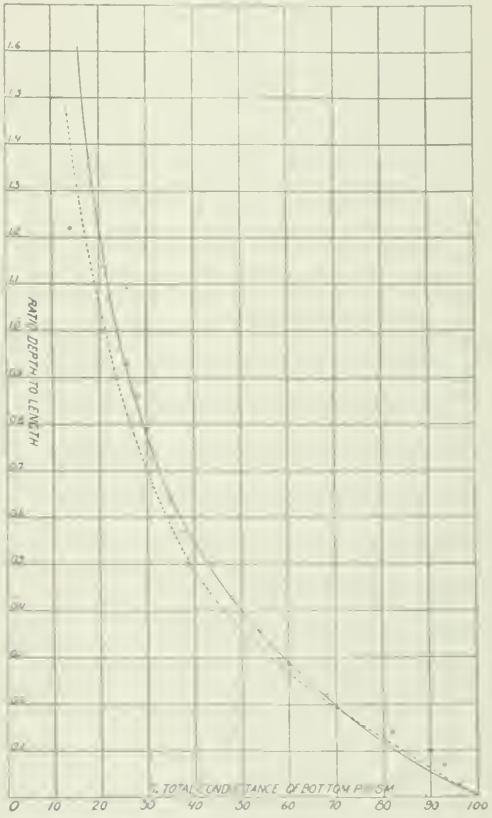


FIG. 2.—RESULTS OF EXPERIMENTS.

formed of the latter recorded. Similar experiments were made with cells of different dimensions.

It was found that while the conductance of the bottom prism was different for different lengths between the plates, its percentage conductance, as calculated above, was practically constant for any given ratio of depth of solution *AK* under the plates to length of solution *AH* between the plates. The authors have, therefore, plotted, in Fig. 2, the percentage conductance of prisms below the plates, taking as ordinates the ratio of depth to length and as abscissas the percentage as calculated above.

For zero ratio the conductance is, of course, 100 per cent, and for an infinite ratio it is zero. An interesting observation is that for a given conductance between the plates the conductance of the prism below the plates reaches a maximum at a finite increase in depth and then after remains constant. In several of the authors' experiments this maximum conductance was reached with a ratio of depth to length of approximately 0.5. They have plotted, in Fig. 3, the percentage which the actual conductance bears to the determined maximum for the prism beneath the

plates, the ordinates again representing the ratio of depth to length and the abscissas the percentage of the maximum.

In order to determine whether the conductivity of the electrolyte affected the values determined as above, they tested electrolytes of widely varying conductivity with approximately identical results, and, furthermore, tested sheets of copper, tin foil and zinc, the most careful experiments being made with zinc, and the ratio determined from it practically duplicated the ratios obtained from the copper sulphate electrolyte. The results obtained on the zinc are shown in Fig. 2 by the dotted line

In cells in which the electrodes did not exactly fit the ends they also attempted to determine the conductance of the prism of electrolyte not directly underneath the electrodes, but to one side, i.e., Fig. 4, the prism *CNOKLGPQ*, diagonally under the electrodes and which may be considered to have connection with the electrodes at the corners *C* and *G*. In making these determinations electrodes *ABCD* and *EFGH* were used smaller than the ends of the cell and were also raised up successive centimeters, leaving besides the prism *ABCDEFGH* directly between the plates and the side prisms *CDKSLGFT* between the edges of the plates and the side of the tank, the bottom prism *BCMNQRHG* between the bottom edges of the plates and the bottom of the tank, and the diagonal bottom prism *CNOKLGPQ*. The conductance of the cell being measured for each successive withdrawal of the plates, the sum of the conductance of the prisms between the electrodes, at the side of the electrodes and directly under the electrodes, was subtracted from the measured conductance in order to determine the residual conductance ascribable to the bottom diagonal prism. The number of factors to be considered in this measurement left the determination of the conductance of this bottom diagonal prism rather unsatisfactory. From three or four carefully conducted experiments the authors can but say that the conductance of such a relatively large diagonal prism as would be encountered

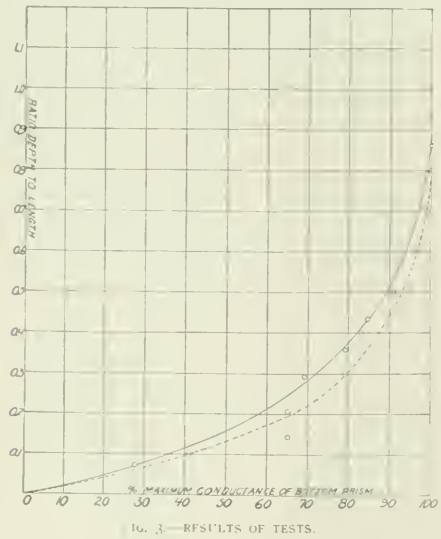


FIG. 3.—RESULTS OF TESTS.

in practice does not appear to add sensibly to conductance of the cell as a whole.

Practical Conclusions.—There results from this study the conclusion that the practical conductance of the electrolyte situated between the two electrodes, both directly, lateral and beneath the electrodes, can be calculated by adding to the conductance of the portion between the plates the conductance of the side and bottom prisms as determined in each case by calculation from the respective conductance of the prisms as if between parallel plates and the use of the constant as given in the curve in Fig. 2. It is only necessary to find the ratio of depth (distance from edge of plate to side or bottom of tank) to length (distance between the plates), to refer to the curve and to find the percentage of total conductance o feach prism actually available. The conductance of the diagonal bottom prism may be neglected in all cases in actual practice.

The fact that there is reached a maximum conductance after

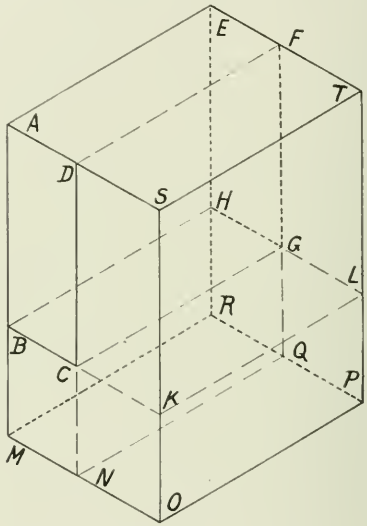


FIG. 4.—ARRANGEMENT OF EXPERIMENTS.

a given depth, holding for electrolytes and metals both, is important as showing the uselessness of increasing the depth of the electrolyte underneath or at the sides of the electrodes past a certain point, such increase in dimensions adding nothing to the conductance. The uselessness of increasing the depth (width) of an electrical metallic conductor conducting between points of contact at the two ends on the same side, beyond a certain depth which is approximately the ratio of depth to length of 1/5, is quite as important for the electrical engineer, in the design of equalizing bars and heavy busbars of short length, and shows the great importance of making contact over the whole end or face of the conductor in order to get the full utilization of the metal comprising it. Connection should never be made along an edge or at the corners.

The papers of Professors Richards and Landis was discussed at some length by Dr. W. R. Whitney, Mr. Townsend Wolcott, Dr. M. Loeb, Mr. E. A. Sperry, Mr. Carl Hering and Dr. L. H. Baekeland. Dr. Richards replied for the authors.

Prevention of Corrosion of Steel.

The last paper of the Saturday morning session was presented by Mr. Maximilian Toch on a new method of preventing the corrosion of steel. This was based on an observation made by Mr. E. A. Sperry to the effect that pieces of steel, obtained from detinning tin scrap, were rendered immune against corrosion by treatment as cathode in a sodium carbonate solution of certain concentration at a low voltage and a high amperage. Mr. Toch has made experiments along the same lines and thinks that such a method may prove practical for protecting bolts, nuts, screws, etc., against corrosion.

In the discussion, Mr. Gaines suggested that in some cases of corrosion bacteria play a part. Mr. Toch affirmed this for some cases of corrosion of copper The paper was also discussed

by Messrs. Sadtler and Sperry. Mr. Sperry will present a further paper on this subject at the next meeting.

The first two papers of the afternoon session dealt with dry cells, one by Mr. F. H. LOVERIDGE, with "dry-cell tests," the other by Prof. C. F. BURGESS and Mr. CARL HAMBUECHEN, with "some characteristics of dry cells."

Dry Cells.

Mr. F. H. LOVERIDGE, in his paper, thought that it would seem to be a very desirable thing to have dry cells rated on an amp-hour or a watt-hour basis under some definite condition of energy discharge, but such a thing is practically unknown at the present time. The rating we now have is that of dimensions of the cell and its current. The first might be accepted as reasonable, but the second is misleading. Amperage ratings are high and apparently based on the instantaneous current a cell will give when short-circuited through a low-resistance ammeter. Such readings are of practical value in discovering defects, but so far as determining an energy output is concerned they are of little value.

The "shelf test," or, in other words, the test made after a cell has remained for a certain time in storage, is one that serves a useful purpose for the reason that it is desirable to know the change that takes place during such period. Very few cells go into service immediately after they are made and during the delay more or less deterioration takes place. But in such tests high-resistance voltmeter and a low-resistance ammeter should be used—a minimum of 150 ohms for the voltmeter and a maximum of 1/100 of an ohm for the ammeter are found to be satisfactory values.

Taking everything into consideration, Mr. Loveridge comes to the conclusion that the best shelf test is one that compares the actual performance under working conditions of the cell after a certain length of time on shelf with that of a new cell. In this way results are obtained that involve no factors of uncertainty. There is involved in this the using up of cells to find out what they will do on life test. Such procedure, however, seems necessary since other methods involving tests not absorbing energy are not dependable and sample cells used up on life tests do not represent very great expense.

Deterioration is shown by an increase of internal resistance inasmuch as voltage readings decrease very slightly on shelf. It is impossible to give any exact data as to the increase of internal resistance on shelf because there is such a wide variation even in cells of the same make, but, roughly, it might be said that a reduction in the short-circuit current of 50 per cent would be a fair average in one year at ordinary temperatures.

Life tests are often made on dry cells by connecting them permanently in circuit with a fixed resistance. This method is the easiest one to employ as it requires no attention other than the taking of readings at the desired intervals. Such a test is of no great value, however, as the energy output is small and the life very short unless the current is kept low. Under these conditions the staying qualities of the cell are not demonstrated and the ability of the cell to stand up under ordinary current drain after a considerable period on "open-circuit" service cannot be predicted with safety.

There is a wide variation in the energy derived from cells discharged with constant resistance down to 0.5 volt under these varying conditions. The value of the energy output in different cases has been figured to a point at which the potential difference has fallen to 0.5 volt and is found to be as follows:

With	1	ohm	7 watt hours.
"	2	ohms	8
"	4	"	14
"	6	"	21
"	10	"	24

As the "closed circuit" test is not a safe one for "open circuit" work, the best test to be applied is the "open-circuit" one in which the cell may be made to show what its life characteristics are when its energy is used over a relatively long period. Sample cells are generally taken for this purpose, and tests should duplicate working conditions as nearly as may be. Some form of clock-controlled contacts are very well adapted to this purpose and may be made to control the open and closed-circuit periods in any manner desired. It is also a good plan to use relays controlled by clock contacts for closing the test circuits. By this means the master or pilot contacts on the clock are only used for light currents, and it is much easier to maintain them in good condition. The mechanism and contacts should be well made and reliable, as it is difficult at best to get consistent results. The shorter tests, as a rule give results more satisfactory as regards uniformity than long ones—the chances for variable factors entering being greater with increased time.

In taking readings on dry cells it is, of course, necessary in either "closed" or "open-circuit tests" to have some form of voltmeter to measure the e.m.f. It is also desirable to use such an instrument for current readings employing the fall of potential method, as this enables current readings to be taken without disturbing circuit connections. If an ammeter is inserted in circuit from time to time, there is a tendency to vary contacts and resistance. Anything tending to introduce variations should be carefully avoided.

Mr. Loveridge showed numerous curves giving the results of various tests. From one of them it was seen that there is a continual increase of the internal resistance of a dry cell as energy is given out. The internal resistance is very low when the cell is new; as the cell grows older on the shelf the resistance is continually increasing, though to a much smaller extent, than when it was on even very light service. The internal resistance depends, both on life and service.

Another set of curves of Mr. Loveridge showed the results of intermittent tests. Other curves referred to ignition service. It is difficult to form an adequate idea of the energy requirements for ignition service. The resistance as well as adjustment of spark cells is very variable and the time of service, as, for instance, in automobile work, is apt to vary between wide limits.

In striving to obtain the highest efficiency, it is necessary to know working conditions, such as current drain or resistance of circuit and the frequency and duration of circuit closure. Knowing these factors, the proper arrangement for the required number of cells can be made to obtain the best results. It is frequently found that cells in parallel may be advantageously employed for the reason that excessive current drains may thus be avoided. The characteristic action of cells indicates that under heavy current drain the fall of potential is rapid and the energy obtained is small, hence the plan of placing "enough" cells in series may not be advisable. A high potential may be maintained by placing cells in parallel so that the current drain on each will be light. Such a plan utilizes the energy available in a far more efficient way.

Tests are sometimes made in which a fixed current is caused to flow, but in order to accomplish this, the resistance must be constantly changed. Such tests are interesting, but the conditions are not those ordinarily met in practice. A constant current flow is desirable, however, and a very close approximation to it may be made with dry cells, provided they are arranged for the high-level rate of discharge.

One of the important factors in obtaining data from dry cell tests is the "cut off" point, or, in other words, the value to which the potential difference of the cell may be allowed to fall before it is considered exhausted. The lower a cell is run, the greater will be the energy obtained, but this is offset by the greater variation in potential difference. Hence a compromise must be made. A study of conditions must govern the selection of this point in various classes of service, but it should be remembered that it involves one of the most important elements in obtaining best results.

The battery case is a factor in the situation that must be con-

sidered. As a rule, these instruments are constructed as a species of volt-ammeter in that they are either high-resistance ammeters or low-resistance voltmeters. As they are not expensive it can hardly be expected that they will compare favorably with Weston instruments in exactness of indications. The scale divisions generally indicate amperes, and the intention is to show what current would flow if the cell were short-circuited through a low-resistance ammeter. The coil of the battery gage being of only a few ohms resistance, there will be a variation in current depending on the internal resistance of the cell—the deflections of the needle will be approximately proportional to the current strength. When the internal resistance has increased to a considerable extent, the battery gage is capable of giving a good indication of it. Thus, when a cell is exhausted, a battery gage is convenient and fairly reliable for indicating the condition of the cell.

Battery gages are not reliable for detecting small variations in the condition of a cell, nor for determining accurately any exact condition. Where exact conditions are desired, the best that can be done is to allow the normal working current of the cell to flow and then take a potential difference reading with a standard high-resistance voltmeter. Such readings give the best indications of the stage a dry cell has reached in the period of its useful life.

In conclusion, Mr. Loveridge expressed the hope that before long some standard tests may be proposed which will be generally accepted as determining the rating of dry cells. The number consumed annually is enormous and users are obliged to accept them with no information which will give a definite idea of energy output. They must judge of this by experience. The art of manufacturing dry cells has progressed to such a point that a reliable product is obtainable, and dry cells should fall in line with other electrical products as a standard article with a definite rating.

The paper elicited quite an extended discussion, in which Dr Baekeland, Dr. Waldo, Mr. Loveridge, Dr. Sharp, Professor Burgess, Dr. Whitney, Mr. Hering and Dr. Elliott participated. Professor Burgess spoke of the advantages of constant-current tests, but Dr. Sharp thought that the main argument in their favor was their greater convenience with a number of cells connected in series, while constant-resistance tests resemble more nearly the conditions of practice.

Mr. Hering moved that the society should undertake the formulation of standardization rules on dry cells. This motion was seconded by Dr. Whitney, who emphasized that it was the duty of the society to undertake just such work.

The motion to appoint a committee for this purpose was carried unanimously

* * *

A paper by Prof. Charles F. Burgess and Mr. Carl Hambuechen discusses the desirable characteristics of a dry cell, which naturally depend upon the service with which it is to be associated.

Dry cells are used in the telephone field, in ignition service, electric-bell and annunciator work, with telegraph and alarm circuits, electric clocks, phonographs, etc.

The primary requisites of a dry cell are its ability to live over a long period of time, a low internal resistance, minimum polarization and rapid recovery. It is impossible to point out which is the most important of these qualities, since the relative importance depends upon the character of service required. Among the minor characteristics which are sought to be attained in dry-cell construction are: Absence of the leakage of the liquid, minimum increase of resistance with low temperature, convenience for connecting into circuit, and the general appearance of the cell.

The factors which govern the above characteristics include these: Materials employed in construction, the proportions of materials, the chemical and physical qualities of these materials, methods of assembling.

In spite of the fact that 40,000,000 or thereabout represents the number of dry cells manufactured each year in this country, little scientific work has been done in the way of making a detailed study of the various individual factors which influence the quality of the cell, if we may judge by the meager publications. On the other hand, much scientific work has undoubtedly been done, if we may judge by the marked improvements which have been effected in the product. It appears that dry-cell manufacturers who are doing the larger part of this work do not feel inclined to discuss analytically dry-cell construction.

Perhaps 80 per cent of the dry cells made and used are of the so-called No. 6 size, being in cylindrical form, the zinc container 6 in. high and 2½ in. in diameter. As far as the cylindrical zinc container is concerned, there is striking uniformity in dimensions and construction, the principal difference being in the thickness of the zinc, which may be found to vary from No. 7 to No. 11 sheet zinc gage.

All cells employ a carbon rod for the cathode plate. In some forms of cells this rests on the bottom layer of paper, and in others it is raised ½ in. from the bottom. It extends up through a pitch seal, and a brass cap or brass screw attached to the top constitutes the positive terminal of the cell. Some of the carbons used are of smooth cylindrical shape, while others are corrugated or flutted to give greater contact surface to the filling material.

Another striking similarity in most of the dry cells is the list of materials which are introduced into the zinc container. Similarity then ceases, and we encounter variations in the quality of the materials, the proportions, and in the methods in which the materials are introduced into the container.

The following list and proportion of materials may be taken as fairly representing the filling mixture in well-known types of cells: 10 lb. of manganese dioxide; 10 lb. of carbon or graphite, or both; 2 lb. of sal ammoniac; 1 lb. of zinc chloride. Sufficient water is added to give proper amount of electrolyte to the cell, and the most suitable quantity depends upon the dryness of original materials, fineness, quality of paper lining, etc.

While these are the essential elements, other materials are frequently added—such as starch or other forms of paste, to improve contact of electrolyte to zinc and promote distribution of action throughout the charge. Mercury is occasionally added to effect amalgamations and prolong life of the zinc.

With the materials as above listed and in the proportions named the resulting cells may be good or they may be practically worthless, depending upon various factors. It is generally believed that purity of materials is the pre-eminent requisite. Commercial conditions, however, prohibit the use of chemically pure materials. The customary specifications for manganese dioxide calls for a granulated or powdered material having about 85 per cent of MnO_2 and less than 1 per cent of iron. This is a specification which can readily be complied with, and by careful selection and concentration it is possible to get as high as 92 per cent.

Physical qualities, porosity and size of grains are likewise important. The amount of available MnO_2 differs according to the chemical test employed, and "available MnO_2" by test may not be the available MnO_2 under the conditions existing in the cell. In storage batteries PbO_2 is an active material only when in suitable contact or proximity to grid or framework of the positive plate; and MnO_2 in a dry cell is active to a degree, depending upon its contact with the conductive carbon constituting the negative electrode. It is evident that penetration into the interior of a piece of MnO_2 is necessary if the entire mass is to be active; and porosity seems, therefore, to be important.

The purpose of the manganese is to effect depolarization, and thereby to maintain the voltage of the cell during discharge. The qualities designated "minimum polarization" and "great recuperative power" are dependent largely upon the amount and availability of the MnO_2 employed.

Carbon in a powdered or granulated form is employed to give conductivity to the mass of MnO_2 and to furnish a large amount

of cathode surface. Retort carbon, coke, petroleum coke and ground carbon rods and electrodes are the various grades of carbon commonly employed for this purpose, and much of the variation found in dry cells is due to varying qualities of this carbon. Graphite is another form of carbon extensively employed in dry cells, and the more recent improvement in dry cells is undoubtedly due largely to the liberal use of this highly conductive though more costly form of carbon.

Sal ammoniac of a very pure grade is generally employed, and in addition to purity, the physical qualities of dryness and freedom from lumps are requisite to ensure proper mixing with the carbon and manganese.

The zinc chloride is also required to be of high purity and to be free from iron.

Sheet zinc constitutes the anode and serves at the same time as a container. Purity is naturally of importance. The purchaser does not have, however, a variety of grades of zinc to choose from.

This anode makes contact with the electrolyte in the form of paper saturated with solutions of zinc and ammonium chlorides. Ideal conditions call for a corrosion of zinc only in amount equivalent to the current delivered to the external circuit. Excess of corrosion above this amount is caused by local action, and one of the principal problems in dry-cell manufacture is to reduce such local action to a minimum.

Local action is caused to a small extent only by solder, although the latter is decidedly electronegative to the zinc, but it is composed of two metals, lead and tin, both of which have high "over-voltages," which almost entirely prevent current flowing to these metals at the expense of and under the e.m.f. set up by the zinc. Some experimental cells made from sheet zinc streaked with solder on the inner surfaces showed little if any abnormal deterioration due to local action even after standing for several months.

On the other hand, copper or iron, but especially copper (which may occasionally find its way from the brass terminals into the cell), when coming in contact with zinc will set up destructive local action.

It occasionally happens that some of the filling material, the manganese oxide and carbon, gets between the paper lining and the zinc. This naturally gives rise to damaging galvanic couples. Also inequalities in the zinc itself may cause certain differences in potential.

If we were to assume all inequalities of the zinc electrodes to be removed, we still have opportunities for local action due to inequalities in the electrode on the other side of the soaked paper. Non-uniformity in the mixture is detrimental. Some manufacturers place the carbon rod in direct contact with the saturated paper resting on the bottom of the cell, the mixture surrounding it. This must necessarily give rise to some difference of potential, and a measurement of this gave a value of 0.176 volt, in such direction that current tends to flow from the carbon through paper to zinc, thence through paper to the manganese mixture and back to the carbon. To prevent this source of local action is probably the reason for the majority of cells now being made with the mixture interposed between all portions of the carbon surface and the paper.

While the carbon rod is generally considered to be the cathode, the really active cathode surface must be considered to be of a more extended structure. The carbon rod is surrounded by a mass of material—carbon, graphite and manganese—possessing metallic conductivity even though moistened by electrolyte. It would, therefore, be more accurate to consider the active cathode surface as that portion of the mixture just within the paper. While this may be the main cathode surface, it is not exclusively so, and the active surface progresses inward as the action of the cell goes on.

The cathode is a compound one, consisting of an intimate mixture of conductive carbon and graphite in contact with manganese oxide, and the e.m.f. of the cell is the summation of the electrode potentials, 0.56 volt for the zinc (against Ostwald's standard electrode), and about 1 volt for the carbon-manganese oxide mixture, or a combined voltage of 1.56.

While the cell delivers current to the external circuit this voltage decreases, the rapidity depending upon the amount of current drawn. If it were not for the manganese dioxide the drop in the voltage would be very rapid, and the value of the cell is, therefore, dependent largely upon the active manganese oxide or depolarizer. This manganese oxide is consumed. As commonly stated, it is reduced to Mn_2O_3, and in undergoing this change it becomes inactive both as a depolarizer and as a conductor. It is probable that the MnO_2 possesses sufficient metallic conductivity to contribute something to the conductivity of the cell, and when changed to the lower oxide it loses this conductivity. It thus becomes inert and occupies valuable space. It is natural to assume that the MnO_2 in the outer portions near the paper is the first to become reduced, the action progressing inward to a certain depth, this depending upon various factors, such as the intimacy of contact between the carbon and MnO_2, the purity, fineness and porosity of the latter, etc.

If the MnO_2 possesses metallic conductivity and makes contact with conductive carbon and both are moistened with electrolyte, there is a possibility that a certain amount of chemical action occurs owing to the voltaic couple thus produced.

A typical dry cell gives from 10 amp-hours (when short circuited and run down in one hour) to 30 amp hours. The open-circuit voltage is 1.5 or 1.6. A fair figure for the effective voltage during useful life is 1 volt for a discharge rate of 30 amp-hours, so that a fair energy rating is 30 watt-hours. During life the resistance of the dry cell increases, partly due to drying out, but more so on account of other reasons, like the partial reduction of MnO_2. Another reason is the accumulation on the surface between the paper and the zinc of non-soluble impurities of the zinc and the various basic salts and double salts resulting from the electrolytic corrosion.

When a cell is first made up, the paper is saturated with a solution of zinc and ammonium chlorides. More zinc chloride is added as a result of the corrosion of the zinc. The increasing concentration of the $ZnCl_2$ in the presence of the ammonium chloride gives just the conditions which are needed for the production of various double chlorides, some of which are much less soluble than the single chlorides.

These insoluble double chlorides occupy the pores and spaces in the paper, crowding out the electrolyte and increasing the resistance. If ammonia is liberated, it may react with the $ZnCl_2$ to form a precipitate of $ZnOH$, which likewise clogs the cell, unless sufficient ammonia be present to redissolve this precipitate. That this clogging action occurs at the paper and proceeds inward toward the carbon rod is evident, since in taking apart a run-down cell there is usually found a hard crust of $\frac{1}{8}$ in. or more in thickness just inside the paper.

It is no doubt true that improvement in dry-cell construction must come through reducing this accumulation of insoluble non-conductive material. It may be suggested that this precipitation due to double chlorides might be delayed by using only NH_4Cl in the electrolyte to begin with, and, in fact, a somewhat greater amp-hour output can be obtained in this way. But it involves the more serious disadvantage of shortening the life of the cell on open circuit. The presence of $ZnCl_2$ in the electrolyte decreases in marked degree the local action.

The authors conclude that, although marked improvements have been realized, there is still need of and a possibility for improvements. A new method of rating dry cells by energy output should also be adopted. This can only be done after determining and generally adopting the standard methods for conducting tests.

This paper was also discussed at some length.

Nitric Acid from Air.

A paper by Dr. Schonherr described in great detail "the manufacture of air-saltpeter by the process of the Badische Anilin und Soda Fabrik."

Since all the essential technical details described in the

paper were already given in an illustrated article on page 245 of our June issue, reference to this article must suffice here. It should, however, be stated for those especially interested in the subject of fixation of atmospheric nitrogen, that the paper is quite elaborate and covers 34 pages.

Power for Electrolytic Copper Refining.

Mr W. L. Spalding, of the University of Buffalo, presented an interesting paper on this subject.

Power is an important item in the cost of electrolytically refining copper. Per ton of product it is less than in many electrochemical industries, since with soluble anodes the voltage factor of the power is used mostly in overcoming the ohmic resistance of an electrolytic and metallic circuit and meets no opposing electromotive force from decomposition of the electrolyte. Nevertheless, this item is in round numbers 40 per cent of the cost of converting anode to cathode copper, or 20 per cent of the cost including furnace treatment. Its relative size, though not its actual, is increased by the extensive use of labor-saving machinery and mechanical handling of material. This use has been so far perfected that further reduction of costs must most easily be obtained through lower power charges.

In securing cheap power, there are several considerations which greatly aid the refiner. First, the unchanging resistance and the continuity of the process allow a constant load day and night, and the steadiness and magnitude of the power used insures the economy either of its generation at the plant or of its purchase from a power company. Secondly, waste-heat boilers on the reverberatory and cupola furnaces furnish considerable power at little expense, since the item of fuel is entirely eliminated from its cost, and were there a sufficient amount of it, the refiner would not need to seek farther. Its one disadvantage is its irregularity. For several hours during the day the furnaces are being dipped, charged or repaired, and furnish little steam, while for a couple of hours in the morning during poling they give a large quantity. The amount of this power available for electrolytic work depends upon the material treated at the refinery; one commencing with pig copper or anodes, as is usual in the East, receives relatively a much smaller amount than one smelting ores or concentrates.

Power for electrolysis may be either generated by steam engines, gas engines, or hydraulic turbines, or purchased from a power company. Steam engines, because of their reliability, are most commonly used; any available steam from waste-heat boilers may be used in them directly by connecting these boilers in parallel with the coal-fired boilers, or the former may be used as preheaters and connected in series with the latter. Both reciprocating engines and turbines are met with, but the former more frequently, because of their high efficiency at full load, the availability of floor space at a smelter, and the lower speed which allows them to be direct connected to the direct-current generators.

The high thermal efficiency of gas engines suggests, as an attractive possibility for a refinery, a central battery of gas producers, which furnishes both power for generating electricity and fuel for heating the furnaces.

The purchase of electric power from a power company is very desirable electrically and under some conditions is the most economical. If alternating-current power is received, the units for supplying the tank house circuits are synchronous-motor generator sets which give a high efficiency of conversion, a 100 per cent power factor, great facility of operation and regulation, and practically uninterrupted service. A refinery thus equipped should be the most favored customer of the company, as with proper regulation the load curve is absolutely flat, and no interest charge on machinery held in reserve can equitably constitute a portion of the rates.

Moreover, the refinery may be used for filling up the valleys in the company's load curve and the refiner may be able to contract for additional blocks of power, at such times as the company directs, for a figure lower than for his steady 24-hour load. It is true that the current density will increase at these times, but as the deposition of copper can proceed satisfactorily under a wide range of current density, this fluctuation is not open to the same objection as in processes that require a fixed minimum voltage or a constant supply of heat.

A calculation of the saving from this cheaper power should involve the consideration that the cost of power per ton of copper is nearly proportional to the current density, and too great an increase in the density will overbalance the lower rate.

On the other hand, other steps may be taken to materially lessen this increase. The tanks with insoluble anodes used for depositing excess copper from the electrolyte may be placed in circuit only at these times; each consumes about eight times the energy of the ordinary tank, due to electrolytic decomposition, so that if their number is 2 per cent of the total, their resistance is 14 per cent of the total. A certain number of other tanks are also regularly short-circuited during the day for cleaning. Also it must be borne in mind that the current density is proportional to the square root of the power and hence its variation is less than that of the power.

In Buffalo the cost of Niagara Falls power in lots of 500 hp or over is $27.50 per hp-year, which converted to direct-current at 87 per cent efficiency equals $31.60, surprisingly large for a region situated near a source of vast water-power. Unfortunately for the consumer, there is but one company owning a franchise in the city, and it has been able to keep the field free from rivals and itself from adverse legislation. The price of power is therefore determined, not by competition with other power companies, not by cost of production, but by competition with steam-power.

The refiner who wishes to use both waste heat and electric power for electrolysis is confronted by the interesting problem of combining the two so as to secure minimum cost per ton of output. The most satisfactory way seems this—to supply a tank-house circuit with two generators in parallel, one driven by a motor running on a constant amount of the purchased power, the other driven by a steam engine whose load varies with the steam.

This arrangement permits the load to be divided in any ratio between the two generators by hand or automatic regulation of the shunt field rheostats, or the engine to be shut down on Sundays and during the dipping of the furnace charges when the supply of steam is not more than sufficient for driving air compressors, pumps, etc., and heating or evaporating the electrolyte. At large ratios of the two loads the equilibrium is delicate, but not disturbed. When taking the load off both machines and the rheostats are not turned simultaneously, one may overpower the other, but as the direction of rotation of a shunt-wound generator is not changed when run as a motor, no harm is done.

A series arrangement of the generators with half the circuit interposed between them would divide the voltage between the tank-house terminals and decrease the current loss through grounds, but excessive sparking from commutation of the heavy amperage in the weak field would not allow the engine-driven generator to carry as small a load at periods of low steam.

It is not economical to use the waste power on an independent circuit, as part of the time it would receive little or no current; the output of copper with a given power is proportional to the square root of the number of tanks and the electric power could be used to great advantage if spread out over this circuit.

To determine the number of kw-hours to be bought each month, a calculation of the amount necessary for the desired production should be made, the probable power from steam deducted, and the remainder maintained as a constant load on the motor. When the power paid for is the maximum two-

minute peak occurring in the month and these peaks are recorded by a graphic wattmeter, close regulation is essential. This can be obtained by hand regulation aided by a bell alarm, or better still, by an apparatus that automatically changes the resistance of the shunt-field circuit of the generator when the wattmeter on the motor circuit records more or less than the desired quantity. With this attachment, the maximum two-minute variation from the average load will be less than 5 kw. This combination of power necessarily gives a current density greater at night than at day, but the fluctuation is not objectionable and can be decreased as already mentioned. Further uniformity can be secured by using the peak of the steam for storing up heat in the electrolyte at night, and by rearranging the schedule so that the periods of dipping do not coincide.

The practicability of the use of electric power from central stations for refining copper has a direct bearing on a problem that is receiving considerable attention in the industrial world—the problem of meeting, on the one hand, the demands of the electrochemical manufacturer for cheap power, and, on the other, the desire of producers of electrical power to obtain customers who maintain a constant load, or, who, better yet, can use large amounts of it at times when the rest of the producer's load is light. The magnitude of the scale on which electrolytic copper refining is now conducted makes the availability of cheap power an important consideration in the location of the refinery; and at the same time such a plant is an ideal customer for the power company. The existence of these common interests makes certain a mutual profit from their mutual recognition.

Iron Copper Alloys.

A paper by Prof. CHAS. F. BURGESS and Mr. JAMES ASTON of the University of Wisconsin, was presented by Professor Burgess.

The influence which copper has in iron and steel has for long been a subject of controversy and contradiction. It is only comparatively recently that the effect has been investigated systematically and some of the doubt eliminated.

The prevalence of appreciable quantities of copper in the ores of certain districts makes important a knowledge of its effect, detrimental or otherwise, when present in small amounts. Also, the intimate relation of copper, nickel and iron, and the beneficial effect of the addition of nickel to iron and steel, creates an interest in the influence of larger percentages.

The older opinion was that copper was deleterious; that its chief effect was analogous to that of sulphur in that it rendered iron red short and destroyed its welding power. This view was taken by many eminent metallurgists, some even contending that 0.5 per cent makes steel worthless. Others claimed that the influence was greatly exaggerated, and instances were cited where rolled sections of 0.50 to 0.75 per cent of copper did not display red shortness.

Within recent years more systematic investigations have been made to determine the effect of additions of varying percentages of copper to iron and steel. The authors then gave a review of the numerous former investigations on this subject, which were generally made to excuse the presence of copper and steel and to break down the seeming prejudice. They then gave an account of their own experiments, which form part of extended research work carried out at the University of Wisconsin, under the grant of the Carnegie Institution, of Washington (other parts of this investigation have been dealt with in various articles in former issues of this journal). They prepared their copper and iron alloys from electrolytic iron 99.7 per cent pure and pure electrolytic copper. This is of importance as, from the results of former investigations, it appears that the influence of copper on the qualities of steel varies with the amounts of carbon and sulphur present. In the present investigations these were practically eliminated, although some carbon was present; its quantity may be taken as well under 0.1 per cent.

Forging.—Alloys up to 2 per cent of copper forge well at low heats. Those from 2 to 7 per cent will not forge at a low heat, and rather poorly at white heat, the ease of workability varying inversely as the percentage of copper. From 7 to 75 or 80 per cent the alloys may be classed as non-forgeable. Between 80 and 100 per cent they will forge at a fair red heat, but not at a normal forging heat for iron.

Segregation.—The forgeable samples between 0 and 8 per cent of copper and a few of the alloys of high copper and low iron were made into tests bars for investigating the tensile strength. Random samples were analyzed by Booth, Garrett & Blair, of Philadelphia. The results show an exceedingly close agreement between the added copper and the actual copper content found by analysis, which indicates an entire absence of segregation; also that the materials alloy very well up to a copper content of 7 per cent. This is in accord with the work of the earlier investigators.

Hardness.—The hardness tests are merely qualitative, being observations made in the machining, sawing and filing. In machining, the alloys with low percentages of copper worked very easily. The hardness increased with the increase of copper until at 5 to 7 per cent, while it was still possible to turn in the lathe, it was with some difficulty. There were the same evidences in the sawing and filing tests, the high copper being classed as extremely hard to saw. The authors intend to make a metallographic study to explain the hardness.

Tensile Strength Tests.—Of the bars cut from each rod for the tensile tests, an equal number were reserved for tests as forged and after annealing. In annealing, the samples were packed in a magnesia-lined graphite box and were heated in an electric resistor furnace. The temperature was brought up to 900° C. and held at this point for several hours, and several hours were needed for the slow cooling in the furnace. The test samples were approximately from 0.3 to 0.4 inches in diameter, with a free length of 2 inches. The diameter used in the calculations is the mean of several readings with micrometer calipers. The tests were made on a Riehle 100,000-lb power-driven machine. The load was applied very slowly and the beam kept in balance. The yield point was obtained with dividers, and was taken at that point at which a perceptible permanent stretch had taken place. This was checked by the drop of the beam.

The summary of the results of these tests is given in plates I and II (page 528).

The measurements gave the yield point, the ultimate strength, the percentage of elongation in 2 inches and the percentage of reduction of area at fracture. The plates are plotted from the averages of the figures, and it is not to be expected, considering the many variables which might arise in tensile strength tests, that any series will give a simple curve. It is merely hoped to show the tendency of the increasing percentages of copper. The values of the yield point, ultimate strength, elongation and reduction of area are designed as points used in plotting the curves by the appropriate letters Y. U., E. and R.

Unannealed.—From the curves of Table I, it will be noted that the rise in the ultimate strength and the elastic limit is almost a linear function of the percentage of copper. The ultimate strength increases from 61,180 lb. per sq. in. at 0.1 per cent copper to 132,400 lb. at 7 per cent. The yield point rises from 52,580 to 122,000. There is a corresponding fall in the elongation from 28.5 per cent at 0.1 per cent copper to 4 per cent at 7 per cent copper. The reduction of area increases slightly from 69.2 per cent at 0.1 Cu to 72.1 per cent at 0.6 and 0.8 per cent Cu; from this point it falls to 7.3 per cent at 7 per cent copper.

The results of these tests indicate a high tensile strength, which increases with the percentage of copper. The alloys are rather brittle, as indicated by the elongation and the reduction of area. Also the elastic ratio (ratio of the elastic limit to the

ultimate strength) is large, varying from 0.86 at 0.1 per cent copper to 0.93 at 7 per cent Cu.

Annealed.—The results of annealing are given in plate II, and the effect is very marked, especially for the higher percentages of copper. There is greater consistency in the results, as is to be expected, and the points fall fairly well in line on the curves.

Up to 1 per cent copper there is a marked increase of the elastic limit and the ultimate strength with the additions of

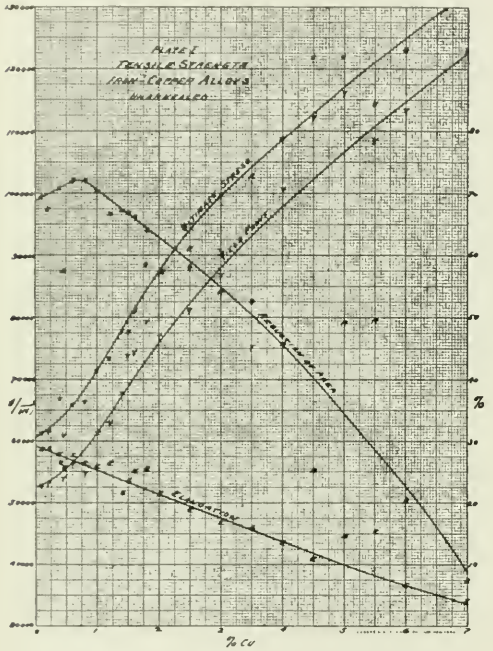


FIG. 1.—TENSILE STRENGTH, UNANNEALED.

copper, and no falling off in the elongation or reduction. In fact, the latter increases to a maximum at 0.4 per cent copper. Beyond 1 per cent the curves bend sharply and become more nearly horizontal, being a linear function of the percentage of copper. The elongation and reduction of area fall off in accordance.

Between 1.5 per cent and 7 per cent of copper the elastic limit increases from 51,570 to 56,950 lb., the ultimate from 65,720 to 67,900 lb., while there is a decrease in the elongation and the reduction of area. Between 0.1 and 1.5 per cent of copper the elastic limit rises from 35,570 to 51,580 lb., the ultimate strength from 54,050 to 65,720 lb., while the elongation and the reduction of area remain about the same. Breuil mentions the 4 per cent alloy as worthy of further study, and this is no doubt true, since he observes very high values. His figures agree well with those of the present authors. But, while Breuil lays particular stress on the 4 per cent alloy, the results of the present authors indicate the greatest value between 1 and 2 per cent for the annealed samples. The very sharp rise of the elastic limit and the ultimate strength at this percentage gives values but very little less than those for high copper content; also there is a removal from the region where the forging and welding properties are poorer with consequent uncertainties of result. Likewise, between 1 and 2 per cent the elastic limit and the reduction of area are very high.

It would hardly be advisable to work with 1 per cent of copper, since this is on the edge of the limit, where there is liable to be a fall to the lower values obtained with lower percentages of copper. At 1.5 per cent we are far enough removed so that the slight differences of composition to be met in practice would not bring the material into a dangerous region. Also, the elastic ratio of 0.78 is slightly lower than for the 4 per cent alloy, where it is 0.81.

The authors state that they would have considerable hesitation in bringing forward this point without a vast number of tests for confirmation, but for the fact that an observation of Breuil's results indicates the same condition.

Another fact to be noted in the tests of the authors is the marked difference between the unannealed and the annealed samples. It would indicate that there is a possible intermediate heat treatment which, not being so drastic in its effect as the long annealing of the authors, would give intermediate values, and thus approximate the nickel steels. This condition might be reached in commercial rolling where heavier masses of metal leave the material in a condition analagous to that resulting from a partial anneal.

To compare the copper-iron with the nickel alloys the authors quote Waddell's extensive investigations. In considering the use of nickel steel for bridge building, he mentions a steel with about 3.5 per cent nickel, carbon 0.38 per cent, the values for which may be taken as, elastic limit, 60,000 lb. per sq. in.; ultimate, 105,000 lb. per sq. in.; elastic ratio, from 0.55 to 0.60. These values are for sections as rolled without heat treatment and working at a somewhat low ductility, as shown by the figures 15 per cent for nickel steel, 27 per cent for carbon steel

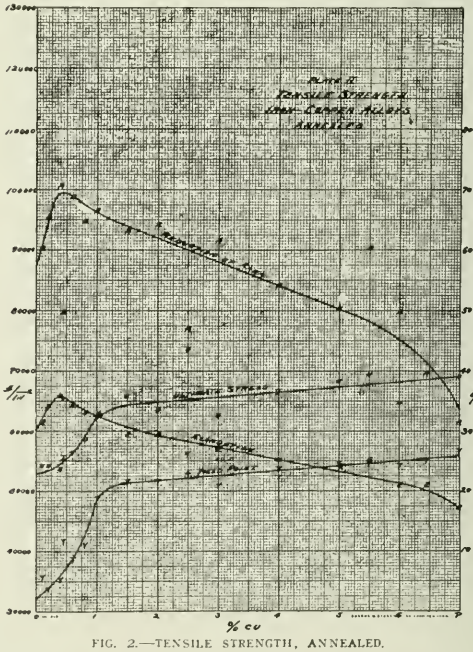


FIG. 2.—TENSILE STRENGTH, ANNEALED.

(in 8 inches) and a reduction of area of 41 per cent for nickel, compared to 55 per cent for the carbon steels. With the carbon reduced to 0.15, the values become—elastic limit, 45,000; ultimate, 70,000; elongation, 25; and for (C = 0.45) the elastic limit is 65,000, the ultimate 115,000 and the elongation 12 per cent.

These values are higher than those of the present authors for the copper iron alloys but are not in direct comparison. The figures of the present authors for a nickel-iron alloy made

under the same conditions as the copper-iron series are given in the following tables, where the 4 per cent nickel is compared with the 1.5 per cent and 4 per cent copper alloys. There is also given Hadfield's test of an alloy of 3.82 per cent nickel and carbon = 0.19 per cent (Inst. Civ. Eng., March 28, 1899)

UNANNEALED.

	Elastic Limit.	Ultimate Strength.	Elastic Ratio.	Elongation Per Cent.	Reduction Area Per Cent.
4.00 Ni	67,900	76,000	0.88	28.5	68.6
1.50 Cu	73,920	77,300	0.95	23.5	45.6
4.00 Cu	105,560	108,640	0.97	13.5	45.6
3.82 Ni	62,720	82,800	0.76	30.0	54.0

ANNEALED.

4.00 Ni	57,000	69,000	0.83	26.5	64.8
1.50 Cu	51,570	65,720	0.79	29.2	63.1
4.00 Cu	53,570	66,540	0.81	24.8	54.2
3.82 Ni	56,000	73,920	0.76	35.0	55.0

The above values for the nickel alloys are less than are commonly assigned to commercial materials where the carbon is a factor. The results are very comparable to those of the copper-iron series made under identical conditions.

Waddell, in his paper, shows that there is an economic advantage in the use of the nickel steels in comparison with the carbon steels ordinarily used, since their increased cost is more than offset by the less weight required, due to their increased strength. The results and comparisons of the present authors would indicate that the copper-iron alloys are also worthy of consideration and might be comparable to the nickel steels in use, even if the strength should not reach such high values as those of the nickel. A 1.5 per cent copper alloy is of promise, since the smaller percentage required and the lessened cost per pound of copper as compared with nickel would result in a lessened cost of construction, even if there is some increase in tonnage required because of the slight decreased strength per equal weight.

In the discussion which followed, Dr. J. W. Richards said that in metallurgical respects the paper of Professor Burgess and Mr. Aston was a very important paper. Much of our steel contains copper (from 0.5 to 0.7), and it has been claimed privately that the copper is not injurious, but rather beneficial. This has now been established by Professor Burgess.

Mr. Aldrich asked about the action of copper in high-carbon steels. Professor Burgess explained that his tests referred to low-carbon steels, the carbon being less than 0.1 per cent. Enough copper steels, containing more carbon, had, however, been made accidentally during the investigation, to make sure that in high-carbon steels copper is detrimental, causing brittleness.

But forging and heat-treatment has much to do with the resulting properties. As to corrosion, they had made very extended tests with a great many copper-iron alloys, which were subjected to various corrosive influences, but the results were not so promising as might have been expected.

Calcium Carbide.

A paper by Dr. M. DEKAY THOMPSON, of the Massachusetts Institute of Technology, deals with the equilibrium pressure of carbon monoxide in the monovariant system consisting of this gas, lime, carbon and calcium carbide, with special reference to the recent paper of C. A. Hansen (this journal, October issue, p. 427). The object of Dr. Thompson's work was to measure the pressure of carbon monoxide in this system for a series of temperatures, from which both the free energy and the total energy or the heat from the reaction could be deduced.

The apparatus used was an Arsem furnace as described by Hansen. It was connected to that end of a syphon barometer which is usually open to the atmosphere, and to a Geryk pump. It was planned to place an Acheson graphite crucible filled with a mixture of lime, graphite and calcium carbide in the helix, heat to a definite temperature measured by a Wanner pyrometer, and read off the pressure on the mercury column. In order to approach the equilibrium from both sides, bottles for generating carbon monoxide from potassium ferrocyanide and concentrated sulphuric acid were connected to the furnace through two soda-lime bottles and a phosphorus pentoxide tube.

In some experiments only lime and carbon or calcium carbide were used, trusting to the reaction to produce the phases that were lacking.

The carbon screen ordinarily used to prevent too much loss by radiation was left out in experiments carried out below 1600° C. on account of the property carbon has of absorbing gases, and consequent uncertainty in the meaning of the pressure readings. The furnace was already evacuated to a pressure of less than a millimeter before beginning the experiment.

When making experiments with a temperature of 1500° C. and upwards, it was always found after each run that a white powder covered the inside walls of the furnace. This is due to the direct decomposition of the carbide according to the equation $CaC_2 = Ca + 2C$, and further combination of the liberated calcium according to the reaction $Ca + CO = CaO + C$. If this is so, the pressure of the carbon monoxide will be reduced below what it should be for equilibrium, and the constant readings will be purely accidental.

Dr. Thompson describes various experiments which show that calcium carbide is decomposed in a vacuum at 1692° C., forming metallic calcium, while in presence of carbon monoxide, the white powder is formed instead of metallic calcium, due to a reaction between calcium and carbon monoxide, which probably takes place as the calcium comes off in the form of vapor. The fact that carbon monoxide unites with calcium is also shown by the drop in pressure when the carbide and the gas are heated together and when at the same time the white powder is found inside the furnace after the run.

Dr. Thompson also shows how completely carbon monoxide can be removed by metallic calcium at a temperature of 1400° C., a pressure of 1 mm of monoxide being reduced to less than 0.1 mm when the temperature was raised from 1300° C. to 1400° C.

The conclusion is drawn that equilibrium conditions cannot be obtained quite so easily with this arrangement and that Hansen's measurements cannot correspond to equilibrium. The only sure way to get equilibrium is to approach it from both sides. To further prove that Mr. Hansen's results do not represent equilibrium, the author calculates on the basis of a formula of Van't Hoff the ratio of the pressure of carbon monoxide for 1800° and 1400° and finds theoretically a ratio of 840, while Hansen measurements gave 3.9.

The paper is summed up as follows: "It is shown experimentally that the equilibrium pressure of carbon monoxide cannot be obtained by heating lime, carbon and carbide or lime and carbon alone initially in a vacuum, on account of the decomposition of the carbide into calcium and carbon and the subsequent reaction of carbon monoxide and calcium. Hansen's results cannot, therefore, represent equilibrium." Dr Thompson's researches will be continued.

In the discussion Mr. Hansen described his experiments and stated that he thought he had found a distinct indication of equilibrium: he reserved his further reply for publication in the *Transactions*.

Electric Smelting of Iron Ore.

A paper presented by Mr. F. R. TAYLOR of Penn Yan, N. Y., pointed out that the necessity for large furnaces for the electric smelting of iron ores will be upon us in the very near future. It is often the case that plans that serve for small demonstrations are not very well adapted for large operations. In this connection Mr. Taylor's carbon bisulphide electric furnace, now in commercial operation, offers some suggestions that may be of use.

Fig. 1 with enlarged bottom shows this furnace with electrodes and broken carbons for their reinforcement. Several years' experience in the use of this means of prolonging the life and regulation of electrodes has demonstrated its great usefulness, and points to its value in furnaces of large size

The new proposed furnace for smelting iron is shown in Figs. 2 and 3; the design is interesting as an endeavor is made to charge the ore and fuel separately and at the same time to make the incoming charge serve to conserve the heat by feeding the fine ore around the periphery of the furnace and subsequently forcing it towards and into the heat zone of the furnace.

As shown in Fig. 2, the electrodes are placed under arches which protect them from the descending material and permit their renewal when necessary. These arches and others protecting the feed screws for forcing the fine ore into the interior of the furnace serve to support the upper brick lining of the furnace. Fig. 2 shows a cylindrical construction resting on arches, through which charcoal or other form of carbon is fed to maintain a vertical column down to and between the main electrodes which is designed in part to prevent the ore from occupying that space and enabling it to form and be maintained as the weakest part of the electric circuit, that is, that portion which is between the main electrodes. Outside of the cylinder just described is a chamber "*u*" into which is fed coarse ore, and, if desired, fluxes. Outside of this again are shown the chambers "*k*" and "*y*", into which fine ore is fed; also fluxes, if desired.

Baffle plates "*p*" are interposed in the walls that form the chamber *k-y*, preferably of triangular shape, leaving a space below them so that carbonic acid gases can pass from the interior to an outer chamber, and in the passage come in contact with the descending fine ore, reducing more or less of it to the state of metal. More or less also of this ore in chamber *k-y* falls through openings under the baffle plates and mingles with the coarse ore in the sections *u*. This carries radiated

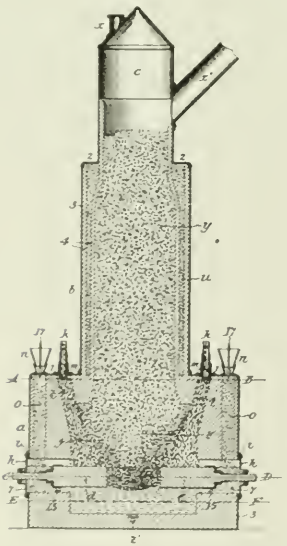


FIG. 1.—CARBON BISULPHIDE FURNACE.

heat towards the interior while its place is taken by cooler ore from above.

Electric motors are shown at *N*, on the outer periphery of the furnace-driving small fans, which return the carbonic acid gas to the interior of the furnace where it may be again reduced to the state of carbonic oxide, and made capable of reducing more ore to the metallic state.

Fig. 3 shows the hearth of the furnace, whose lining consists of carbon electrode, capable of being placed either in circuit with electrodes at the top of the furnace, or with the main electrodes at will. At one side is shown a spout connected with a tap hole for the removal of the molten metal, and in dotted lines directly in front at the back of the structure the tap hole for the removal of slag. It is quite likely that the hip or enlarged bottom (Fig. 1, bisulphide of carbon furnace) would be the better form for a furnace for this work. It is not necessary that the broken carbons should travel the whole distance from the top of the furnace to the electrode, and the hip form would offer better facilities for the removal of the electrodes.

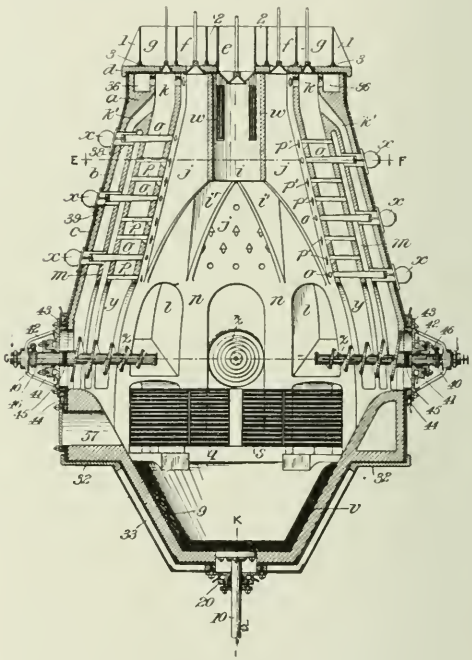


FIG. 2.—FURNACE FOR IRON-ORE REDUCTION.

The screws for forcing the ore forward are shown clearly in Fig. 2. These screws work in the outer and cooler portions of the fine ore and are not intended to be subjected to any considerable heat. They are hollow and may be connected with a blast of air when desired to change the working conditions of the furnace, for example to oxidize the charge to make it less conductive, or to burn out carbon when in excess. Fig. 2 also shows the column of charcoal maintaining itself down through the center of the shaft. Also the demarkation of the coarse and fine ore in their progress.

The discussion of Mr. Taylor's paper was opened by Mr. P. G. Salom, who asked for figures of the number of kw-hours required per ton of ore. Mr. Taylor had these figures not in mind; but he said that the consumption of power is comparatively low and a comparatively small amount of carbon is required, since the operation is relatively simple compared with the blast furnace, there being no large amount of nitrogen to be heated, etc. Mr. Hering remarked that the energy consumption depended to a large extent on the proportion of CO and CO_2 in the escaping gases.

Dr. Richards thought it would be only a few years until several electric-shaft furnaces would be in commercial operation. He did not like, however, Mr. Taylor's scheme of feeding fuel and ore separately, since the fine ore packs and the reducing gases cannot pass through it. In this latter criticism he was supported by Mr. C. A. Hansen, who referred to

some experiments on making ferrosilicon, in which he tried to determine the effect of fine grinding of the charge upon the uniformity of yield and rate of reaction. The charge consisted of scrap iron, silica and carbon, a charge largely used in commercial manufacture. The test apparatus used was the well-known Arsem vacuum furnace, connected to a pump of constant displacement. When the charge is heated and CO is generated by the reaction, the manometer reading, when constant, will obviously be proportional practically, to the reaction rate.

In one case, Mr. Hansen's charge was broken to pass a 1/8-in. square mesh, and the fines which passed through a 1/16-in. mesh were discarded. Manometer readings were taken at various temperatures. In another case the materials were all ground to extreme fineness, briquetted with a very dilute water-glass solution and baked to 960° C. A charge of

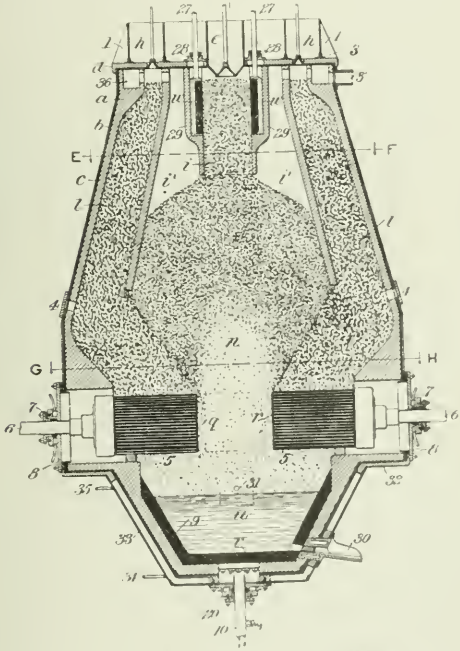


FIG. 3.—FURNACE FOR IRON-ORE REDUCTION.

the same weight as in the previous case was used and manometer readings were again taken at various temperatures. The results in the two cases were as follows:

Temperature	CO Pressure Readings	
deg. C	Coarse charge	Fine charge
1400	0.4 mm	8 mm
1700	3 "	27 "
1900	5 "	60 "
2100	9 "	60 "

In other words the reaction rate which, at the lower temperature depends solely upon contact between solids, is enormously increased by increasing the contact area. Making use of these results Mr. Hansen ran a briquetted charge into a furnace, the charge volume of which was scarcely over 1 cu. ft. (magnetite, however, replacing the scrap iron) at a power input of 100 kw, turned out 50 per cent alloy from this small furnace at slightly more than 2 kw hours per pound, and practically of the composition determined by the charge. The furnace did not get excessively hot, there was very little fume. At this rate the commercial 1000 kw furnaces could absorb nearly 5000 kw. Obviously the losses per unit output are enormously decreased by this procedure, and it becomes merely a case of balancing the cost of grinding and briquetting against the cost of power. In the case of ferrosilicon, so long as no one objects to the fumes, the balance is probably in favor of not grinding charge. Mr. Hansen believes, however, firmly that much is to be gained by bringing the solid reagents into as intimate a contact as possible, in this case, in the case of iron ore reduction and in all similar cases.

Calcium; Anode Effect.

A paper by Dr. FRANCIS C. FRARY and Mr. W. L. BOEGER, of the University of Minnesota, dealt with the preparation of calcium in the laboratory. A valuable summary is first given of former work done by various experimenters. They mention, as the key to success, the method of drawing out the calcium when deposited in form of a rod attached to the cathode (so as to prevent it from redissolving). This is the method used at Bitterfeld, Germany, where calcium is produced on a commercial scale.

The authors used the arrangement of Tucker and Whitney, which they modified in some respects. They had troubles with the anode effect. This "anode effect" is a peculiar and interesting phenomenon, apparently first mentioned by Bunsen, who complains of the interruption of the current, soon after starting the electrolysis, caused, as he thought, by the formation of a layer of either silicon or lime on one of the electrodes. Similar effects have been observed by others.

There have been several theories to account for this phenomenon. In the electrolysis of cryolite, it seems to be due to an improvisement of the bath and is remedied by adding more alumina. (Seligman, this journal, Vol. 7, p. 148.) It has been described as a variety of the spheroidal state, which it certainly resembles in appearance. Borchers ascribes it to excessive current density at the anode, while Willner believes it is due to a layer of silica which he considers would be deposited at the anode if the melt contained a silicate in solution.

With the apparatus of Tucker & Whitney, in several electrolyses of strontium and barium chlorides, each of several hours' duration, the authors never observed the phenomenon, while in the same apparatus they sometimes had much trouble in the electrolysis of calcium chloride. The chloride used was Merck's C. P. anhydrous; analysis of a 6 gm. sample showed the presence of no weighable amount of silica; 0.002 per cent should easily have been detected if present. The anode was always Acheson graphite, and as the inner surface was only very slowly and slightly attacked it seems improbable that the pound or more of the electrolyte could have been seriously contaminated by the traces of silica contained in it, especially as calcium was continually being produced and fresh chloride added.

All the experience of the authors points to the anode current density as being the important factor in the production of this effect. It is quite possible that the presence of excessive amounts of silica might be a contributing case; the formation of a film of silica over part of the anode raising the current density on the rest above the critical point. The detailed explanation of the phenomenon seems to the authors to be as follows:

Under any particular set of circumstances, for any given electrolyte, there is a critical anode current density, above which the gas will be evolved fast enough so that its bubbles unite into a sheet of gas through which the current must pass by means of arcs. This, of course, by reducing the current, reduces the current density but the power consumed is nearly doubled, and all of the resistance and heat is confined to this layer of gas, causing it to be at very high temperature, and thus bringing about the appearance of the spheroidal state.

Some of the electrolyte may be volatilized, too. But as a rule it pays, on account of the loss of current, to run at as low a temperature as possible. (In order to obtain good yield only part of the crucible is

"open," i. e., in contact with fused electrolyte, the rest being frozen. Now, when the anode effect takes place, the "open" surface of the crucible, and the electrolyte next it, are heated very rapidly, hence the adjoining electrolyte in contact with the crucible is thawed and the "open" or active surface of the anode (crucible) is increased. But at the higher temperature now prevailing at the anode, the critical current-density is much lower, hence quite a little of the congealed electrolyte must thaw out before the critical point is passed and the layer of gas breaks. This again allows quiet electrolysis to take place, and on a larger anode surface than at first, hence below the critical density. The melt now cools slowly, gradually decreasing the active anode surface until the effect again appears.

If the current density is the controlling factor, it ought to be possible, by increasing this at any point, to cause the effect to occur. This was easily accomplished; all that was necessary was to momentarily swing the cathode toward the active anode surface, thus altering the lines of current distribution, and the effect could generally be produced at once.

There remain two peculiarities of the effect to be discussed: (1) That it was never noticed with a new crucible, or, as noted by Willner, could be prevented by changing the anode; (2) that if with the same apparatus, the current used was raised to 175 amp or 180 amp, no trace of an anode effect was found. The first is explained by the fact that the crucibles when made did not have a smooth interior surface, and the irregularities, extending into the electrolyte, prevented the formation of the film of gas. As the crucible was used, these were gradually worn off, and the surface became noticeably smoother, allowing the film to form. With the higher current, the temperature of the whole electrolyte was much higher; in fact, almost all of the upper portion of the crucible was "open," and the critical current density was never reached.

Some melting point determinations were made. Two samples of "pure" calcium chloride were tested, giving 766° C. and 755° C. The latter sample contained 0.66 per cent CaO and 0.15 per cent $CaCO_3$.

By adding successive portions of oxide, the authors were able to reduce the freezing point to 705°, where the analysis showed CaO, 6.26 per cent, $CaCO_3$, 3.38 per cent. With more oxide, they began to get a partial freezing at about 770°, while the rest of the melt did not freeze till 705° to 720°, indicating the presence of eutectics.

Electro-Cementizing.

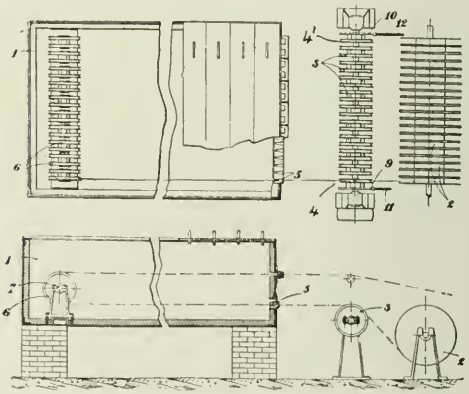
A paper by Mr. Alfred Sang, of Paris, France, describes first the usual hot process of galvanizing iron or steel wire for fencing, barb-wire, etc., by the wet method. There are five operations: annealing, cleaning, fluxing, coating and wiping. The hot process is not a simple one and an expert wire galvanizer is a valuable specialist; it only appears simple and advantageous as compared to more recent processes, because there are two generations of experience back of it. There exists now a demand for something better than the present grade of galvanized wire, and the "electro-cementizing process" is believed to be better. It is soon to be tried on a small commercial scale.

The claims to attention possessed by this process are its comparative simplicity, the fact that it lends itself to scientific control and the qualitiy of the product. It can hardly equal the low costs for hot galvanizing under ordinary conditions.

The principle involved in this new process, which is called "electro-cementizing"—cementizing being the process of depositing metals by cementation, of which sherardizing is a form—is the method of heating by electricity, the heat being directly applied to the articles by using them as resistances. On the very face of it, it is only applicable in practice to articles of small cross-section, such as wires and strips, although in theory it may be applicable to larger goods, and if carried out on a very important scale could undoubtedly be applied to thin sheets and tubes.

Referring to the diagram: the coating chamber or furnace (1) is built of iron plates and lined with refractory material as used in zinc smelting furnaces; it is filled from the top with a mixture of crushed coal and oxide of zinc. The wire comes off the reels (2) and passes over and around brass contact sheaves (3) which are equal in number to the strands of wire which the furnace will treat at one time, and are mounted tight on a common shaft from which they are insulated by non-conducting bushings. This shaft, by revolving, leads the wires and relieves the tension on them. The single sheaves at each end of the shaft (4, 4') are connected through the proper rheostat to the poles of a suitable transformer supplying alternating current at a low tension which may be varied within certain limits. The intermediate sheaves are paired by means of common hubs so that the current may pass freely from one to the other in each pair.

The wires now pass between the hinged aprons or flaps (5) and into the lower part of the furnace, then over another series



PLANT FOR ELECTRO-CEMENTIZING.

of sheaves (6) inside and at the rear end of the furnace, these sheaves being similar in every respect to the double sheaves on the outside, but staggered in relation to them, by which is meant that the near sheave of each outside pair is in line with the far sheave of each inside pair; the wires then return through the upper part of the furnace and through a second set of hinged flaps, to the take-up frame which would, if shown in the drawing, stand to the right of the paying-out reels.

When all the strands of the wire are in place and connected, therefore, in series, the current will pass zig-zag wise in and out of the furnace and a wire resistance of considerable length will thus be afforded. The entire system forms a resistance grid on a very large scale.

As the heating-up is necessarily rapid and as no useful purpose can be served by maintaining the full temperature once it has permeated the wire, it is probable that a very short furnace will suffice.

The details of the operation may be described as follows: The wire is quickly brought to a bright cherry-red, at which temperature all grease is volatilized, scale or rust is reduced by the carbon and occluded gases are driven out; at the same time, the zinc oxide in immedate contact is reduced, and, as vapor, soaks into the "pores" of the metal, which are well opened by the heating, and condenses on the surface as the heat drops. As the wire returns through the upper part of the furnace it cools down slowly from a temperature considerably above its recalescence point, so that it is annealed. With low-carbon steels an excess temperature of 200° or 300° is not likely to seriously affect the quality of the wire. The coating is of the color of freshly electro-deposited silver. The quality of the product is mostly due to the alloy of zinc and iron; the author

claims that iron which has absorbed an almost infinitesimal amount of zinc, by being exposed to zinc vapor in a reducing atmosphere, is most difficult to corrode and resists a solution of hydrochloric acid in a most remarkable manner.

The oxide and finely divided carbon form a non-conducting mass, and the heat emanating from the wires will accumulate in the furnace until a constant temperature, not far below the reduction point of the oxide, will be reached; this will greatly reduce the amount of current required to operate the process. After the operation is under way, the resistance of the hot wires will be much greater than that of the cold wire.

Compared with sherardizing, the electro-cementizing process has a better heat efficiency. While the cost of the furnace will surely exceed that of the hot process, at least until the furnace has reached its constant temperature, the costs of installation, maintenance and depreciation, taken in one with the other, will probably be lower than for the hot plant, the cost of the zinc will be much less, standing at about 3½ cents on a 5-cent spelter market with less waste, and the labor cost should be little, if at all, in excess of what it is at present; the wire will run more slowly, but there will be a compensating increase in the number of strands. Whether practical difficulties will arise with regard to the temperature of the wire and possible breaking of the wire inside the furnace, will be decided by trying the process on a commercial scale.

Two resolutions proposed by Mr Taylor were adopted. One commended the work of the New York State Water Supply Commission and recommended an amendment to the Constitution of the State of New York, which will enable the commission to cut timber and make reservoirs in such reserve lands belonging to the State as the Commission may recommend.

The second resolution viewed "with alarm the possibility of any private interests securing advance control of water rights, coal and other mines of valuable minerals in the Public Lands of the United States, and of the several States," and urged legislation to meet such possible exigencies. The work of the National Conservation Commission and of the Inland Waterways Commission was recommended.

A vote of thanks to all who made the meeting successful was then adopted.

The next meeting will be held in spring, in Pittsburgh, Pa.

In the following we give a complete alphabetical list of all members and guests who registered:

Mr. and Mrs. Paul Abbe, New York City; Dr. and Mrs. F. G. Acheson, Niagara Falls, N. Y.; Miss Acheson, Niagara Falls, N. Y.; Chas. F. Acker, New York City; G. P. Adamson, Easton, Pa.; Mr. and Mrs. L. Addicks, Elizabeth, N. J.; Mr. Aldrich, Elizabeth, N. J.; Thos. B. Allen, Niagara Falls, N. Y.; R. S. Allyn, New York City; Henry E. Armstrong, London, England; Mr. and Mrs. W. C. Arsem, Schenectady, N. Y.; J. W. Aylsworth, East Orange, N. J.; Dr. Bachofner, Dr. and Mrs. L. H. Baekeland, Yonkers, N. Y.; F. Bailey, Perth Amboy, N. J.; Mr. and Mrs. H. B. Baldwin, Newark, N. J.; Harry Barker, New York City; Mr. Barmvoller, New York City; Dr. and Mrs. Chas. Baskerville, New York City; W. H. Bassett, Torrington, Conn.; L. Bates, N. Y.; Mrs. Battin, New York City; Edward R. Berry, Lynn, Mass.; P. A. Boeck, Worcester, Mass.; L. W. Bo art, Jr., Staten Island, N. Y.; Walter Bowman, New York City; George Breed, Philadelphia, Pa.; A. A. Breneman, New York City; C. A. Browne, J. K. Bryan, C. L. Bryden, Scranton, Pa.; Leon H. Buck, New York City; H. Buel, C. F. Burgess, Madison, Wis.; Wm. Campbell, New York City; Henry S. Carhart, Ann Arbor, Mich.; Mr. and Mrs. C. F. Carrier, Jr., New York City; C. R. Cary, New York City; Clinton F. Chance, Oldbury, England; Mr. C. F. Chandler, New York City; W. B. Chapman, New York City; W. C. Chapman, New York City; W. F. Chem, R. B. Chilla, Jr., Cleveland, Ohio; V. P. Christoffauer, Wm. M. Clark, New York City; C. S. Clifford, Mr. and Mrs. W. R. Clyner, Cleveland, Ohio; Mrs. H. B. Coburn, New York City; M. P. Cohn, Toronto, Canada; Mr. and Mrs. H. B. Coho, New York City; W. P. Coho, H. R. Conrad, Pittsburg, Pa.; R. Cory, Philadelphia, Pa.; F. D. Cramer, Montclair, N. J.; F. E. Creighton, Schenectady, N. Y.; J. S. Crider, Cleveland, Ohio; I. L. Crossmay, New York City; Mrs. J. Davila, S. W. Davis, Jr., Indian Head, N. J.; J. B. Dewin, R. A. Dodd, East Orange, N. J.; M. L. Dolt, Dr. and Mrs. Chas. A. Doremus, New York City; J. F. Dowd, Wm. Dreyfus, New York City; Mr. and Mrs. G. Drobegg, Brooklyn, N. Y.; H. Du Bois, O. E. Dunlap, Niagara Falls, N. Y.; Edw. Durant, New York City; Myron C. Durkee, New York City; Mrs. A. S. Dwight, New York City; Mr. and Mrs. M. G. Eckendorf, New York City; Mr. and Mrs. Arthur H. Elliott, New York City; Horace H. Emrick, Mauser, N. J.; V. Englehardt, Charlottenberg, Germany; Ernest F. Eurich, New York City; Albert H. Fay, New York City; B. G. Fernberg, Colin G. Fink, Schenectady, N. Y.; F. W. Fink, F. A. J. FitzGerald, Niagara Falls, N. Y.; Richard Fleming, Westfield, N. J.; Milton W. Franklin, Schenectady, N. Y.; Richard H. Gaines, New York City; Dr. and Mrs. Albert G. Ganz, Hoboken, N. J.; Mr. and Mrs. J. Geissler, New York City; W. T. Gibbs, Buckingham, Ont.; A. E. Gibbs, Wyandotte, Mich.; Miss Mabel Gibbs, H. N. Gilbert, Jacob S. Goldhaum, Philadelphia, Pa.; J. H. Goodwin, East Orange, N. J.; V. E. Goodwin, Schenectady, N. Y.; J. H. Granbery, New York City; Mr. and Mrs. C. A. Graves, Brooklyn, N. Y.; W. M. Grosvenor, New York City; George G. Grower, Ansonia, Conn.; G. W. Gurley, George H. Guy, New York City; Wm. J. Hammer, New York City; Charles W. Hanchett, Pleasant Plain, N. Y.; Miss Hattie S. Hammond, Pleasant Plain, N. Y.; John L. Hammond, Pleasant Plains, N. Y.; W. A. Harris, Kenmore, N. Y.; Mr. and Mrs. J. Hartleith, New York City; C. A. Hartman, Syracuse, N. Y.; Vigo Hansen, New York City; S. C. Hart, New York City; Rayman Hawkes, Tompkinsville, N. Y.; Mr. and Mrs. John Hawkes, New York City; Albert A. Heinrich, New York City; Mr. and Mrs. H. Heiskway, New York City; Percival Henderson, Elizabeth, N. J.; Mr. and Mrs. H. Herring, Brooklyn, N. Y.; Mr. and Mrs. C. P. Hesse, Hackensack, N. J.; Carl Hering, Philadelphia, Pa.; Frank F. Hess, Philadelphia, Pa.; R. S. Hitt, New York City; Harry V. Hoag, Jersey City; William F. Hoard, Denver, Colo.; W. E. Hogan, East Orange, N. J.; Maurice L. Holt, South Bethlehem, Pa.; Edward H. Hotter, Brooklyn, N. Y.; Wm. V. Hotter, Mr. and Mrs. Henry Howarth, Bloomfield, N. J.; Mr. and Mrs. Hoyt, New York City; Mr. and Mrs. W. R. Huey, New York City; A. Innemutter, Buffalo, N. Y.; Mr. and Mrs. Lewis Lawrence Masters, N. Y.; Frederick Isenstein, Port Richmond, N. Y.; Walter H. Johnston, Stapleton, N. Y.; Eric L. Jones, New York City; Mr. and Mrs. C. M. Joyce, Arlington, N. J.; A. L. Kaeser, R. C. Kahn, C. Peter Kahn, New York City; Parker D. Kerr, Buffalo, N. Y.; P. Kerry, Pittsburgh, Pa.; Mr. and Mrs. O. A. Kertes, New York City; Mr. and Mrs. Kenyon, New York City; Edward F. Kern, New York City; A. R. King, Wood Ridge, N. J.; F. Kiesekamp, Mr. and Mrs. F. Mason Kinsman, N. Y.; Theo. Koch, Wm. Koenig, Cleveland, Ohio; Mr. and Mrs. H. Kraus, New York City; V. E. Kraus, L. J. Krug, P. H. Kunz, Brooklyn, N. Y.; Dr. and Mrs. Geo. L. Kunz, New York City; John Lawton, New York City; Mr. and Mrs. Wm. T. Lawrey, New York City; C. Le Boutillier, High Bridge, N. J.; Wm. G. Lewton, Brooklyn, N. Y.; Arthur Livesey, New York City; F. A. Libbey, Niagara Falls, N. Y.; B. Lindsay, Niagara Falls, N. Y.; C. F. Linn, Schenectady, N. Y.; Mr. and Mrs. Loeb, New York City; E. G. Lorenz, New York City; H. W. Lorey, New York City; H. Loveridge, Henry Lyke, New York City; Mr. and Mrs. M. Macdonald, East Orange, N. J.; Mr. and Mrs. Peter Pay, N. Y.; Otto Mallory, Philadelphia, Pa.; J. C. Martin, New York City; Edmund O. Mays, New York City; Mr. and Mrs. F. J. Meyer, New York City; A. S. McAllister, New York City; Mr. and Mrs. McBride, New York City; Dr. and Mrs. Chas. F. McKenna, New York City; H. F. McRae, R. Mercer, East Orange, N. J.; W. H. Merle, Orange, N. J.; H. M. Gloucester City, N. J.; A. Merritt, New York City; Henry G. Morris, Philadelphia, Pa.; Mr. and Mrs. J. T. Morris, New York City; W. R. Mott, Madison, Wis.; C. W. Mueller, Niagara Falls, N. Y.; R. S. Mundton, Poughkeepsie, N. Y.; Ralph E. Myer, East Orange, N. J.; H. Neustaetter, Jersey City, N. J.; Thomas Nevin, New York City; Dr. and Mrs. Wm. H. Nichols, New York City; Edmund C. Nichols, New York City; R. H. Nieler, J. E. Noeggerath, Stonestreet, N. Y.; G. M. Norton, R. S. O., Gl. Lake, Pittsburg, Pa.; J. T. Parker, New York City; L. Pa, N. H. J. C. Pennie, Hobart Pomp, Port Arthur, Ont.; Colonel John Patman, Orange, N. J.; R. Pierce, Orange, N. J.; C. Ole Pihl, Perth, A. F. Perrier, Hackensack, N. J.; A. Pfanz, Dr. Chas. Lorenz, Hausen, Germany; W. J. Rae, Niagara Falls, Ontario; Dr. and Mrs. Frank W. Rane, New York City; Mr. and Mrs. A. R. Ledoux, New York City; A. G. Rieger, Niagara Falls, N. Y.; Mr. F. F. Rogers, New York City; C. M. Rogers, F. W. Rogers, New York City; Thomas Rowlands, Niagara Falls, Canada; J. R. Rowland, New York City; J. B. Rosatore, S. S. Sadler, Philadelphia, Pa.; Peter G. Salom, Philadelphia, Pa.; Jos. Sanno, New York City; Mr. and Mrs. R. F. Schenck, Lake, N. Y.; Walter M. Schmidt, Dayton, Ohio; Mr. and Mrs. J. Schmidt, Brooklyn, N. Y.; C. Schreiber, Hoboken, N. J.; Mr. and Mrs. F. Schreiber, Rutherford, N. J.; Mr. and Mrs. F. E. Scott, New York City; R. C. Sharpe, Alfred P. Scott, Cleveland, N. Y.; R. W. Seabury, J. V. Serle, Syracuse, N. Y.; Harold Mc. C. Sharp, White Plains, N. Y.; S. P. Sharples, Mr. and Mrs. R. H. Sherard, New York City; S. DeV. Shindler, Niagara Falls, N. Y.; Lloyd E. Smith, New York City; Mr. and Mrs. J. Smith, Philadelphia, Pa.; Edmund L. Smith, Niagara Falls, N. Y.; Isaac S. Newark, New York City; Wm. V. Smith, Niagara Falls, N. Y.; C. L. Smith, Philadelphia, Pa.; R. C. Snowden, Niagara Falls, N. Y.; W. I. Snyder, Buffalo, N. Y.; Mr. and Mrs. H. A. Sonn, New York City; Mr. and Mrs. H. J. Speer, New York City; Mr. and Mrs. R. Stacy, New York City; Mr. and Mrs. Starr, New York City; Mr. and Mrs. Stone, New York City; Mr. and Mrs. Stowell, New York City; Mr. and Mrs. Strauss, New York City; Mr. and Mrs. Sullivan, New York City; Mr. and Mrs. Swan, New York City; Mr. and Mrs. Swan, New York City; Mr. and Mrs. Sw

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

The Institute of Metals.

Sir William White presided at the autumn meeting of the Institute of Metals at Manchester, on Oct. 14 and 15, in the hall of the Municipal School of Technology. In his address he said it was evident that there was need of a society to treat with the non-ferrous metals; and to show the necessity for the formation of the Institute he mentioned that whereas the number of members when the first meeting was held at Birmingham last year was 240, on July 1 this year there were 487 members, and more had been admitted since then.

Mr. E. A. Edwards read the first paper on "The Constitution and Properties of the Aluminium-Copper-Tin Alloys," by himself and Mr. J. H. Andrew (which was abstracted in our November issue, page 493).

Dr. H. C. H. Carpenter opened the discussion and said that an enormous amount of work must have been done for the production of the equilibrium diagrams of the ternary alloys. The diagram No. 2 necessitated the making of above 450 alloys. A fact of much scientific interest which had resulted was that tin was totally insoluble in many alloys and separated from them. With aluminium at its present price that fact might have a useful commercial application in the extraction of tin from residues which were not otherwise worth treating commercially. The authors, unfortunately, had not dealt with any large number of alloys having commercial interest.

Mr Sinclair said that in a few investigations in aluminium alloys he had demonstrated the fact that alloys of aluminium and copper lose less in weight in seawater than other alloys; and, forming galvanic couples with them and other metals, he was astonished to discover that an alloy of 90 per cent copper with 10 per cent of aluminium lost nothing in weight.

Mr. J. Brentnall remarked that great difficulty was encountered in making castings of manganese bronze to prevent leakage under pressure. This caused him to turn his attention to alloys of aluminium and tin containing equal parts of each, on account of their peculiar behavior with regard to corrosion. The addition of copper up to about 10 per cent seemed to prevent corrosive action with these, but a further addition did not check the action to a corresponding degree. The addition of zinc to a tin-aluminium alloy largely increased corrosion, and with 95 per cent of zinc to 5 per cent of tin-aluminium the action was so intense that 250 c.c. of hydrogen were collected in half an hour.

Dr. Desch said it was noteworthy that the method of systematic quenching from different temperatures adopted by the authors was introduced by English metallurgists, Mr. Heycock and Mr. Neville, several years ago. The only one of the author's conclusions which he was inclined to dissent from was that a definite compound, Cu_2Al, would separate out. He thought that that compound, if it really existed, was stable only at lower temperatures. But the statement that that compound, Cu_2Al, was homogeneous at 550° C. and at 900° C., and yet broke up at intermediate temperatures was of high scientific interest because it varied from previously known facts and vitally affected the theory of metallic solid solutions.

Mr. Hudson said the gamma phase destroyed the utility of the alloys, and it was most important that the point at which the brittle phase appeared should be determined.

Sir William White considered that many interesting points were raised by the paper, and he regretted the absence of Dr. Rosenhain, who was making investigations for the alloys research committee of the Institute of Mechanical Engineers. The results would be very shortly communicated to that Institution, and would be found to be of great interest.

Dr. Rosenhain wrote to express his disappointment that the paper expressed mostly statements of results instead of data which would have been of great value. Should the authors' results require modification, the absence of data would reduce the value of the paper as an assistance to subsequent investigations.

A paper by Mr. E. L. Rhead on "Some Causes of the Corrosion of Copper and Brass," followed. (It was abstracted on page 493 of our November issue.)

Sir Gerard Muntz said that condenser tubes seldom pitted on the steam side, and when that did occur it was almost always due to the use of bad oil. Tubes pitted mostly on the lower side, because naturally the deposit fell there, and the deposit caused the trouble. Pitting in lines arose chiefly from continuous deposits lying in the tube in conjunction with the spills on the inside surfaces, caused by adhesion of particles of the cores in casting, which were elongated as the result of drawing. The author suggested that nodules of copper were occasionally present in tubes, but these where really places where the zinc had been removed and the copper left. In almost every case the deposits were due to impurities in the circulating water, and in all such cases the corrosive action was caused by the formation of galvanic couples between the zinc and the carbon or the iron. Corrosion also resulted from the decomposition of air and gases when overheating was consequent on too slow circulation. Trouble had also arisen from bad formation or situation of the water intake causing the introduction of much free air, and in such a case alteration of the intake had totally removed the trouble. Some of the tubes returned to his firm as defective had been found to be almost filled with shrimps and seaweed. With regard to the corrosion of Muntz metal—sheathing, bolts and under-water fittings—he could state that this mischief began to appear simultaneously with the use of electrolytic copper in 1888, when his firm made a very close inquiry, the result of which showed that corrosion was due, firstly, to the use of electrolytic copper, and, secondly, to the use of inferior varnish for fastening the sheathing. Smelted copper and Stockholm tar only ought to be used; other materials resulted in the formation of galvanic couples.

Mr. Bengough said that the electrolytic theory of corrosion was now accepted, and appeared to indicate how corrosion might be prevented. Hard material was generally electropositive to soft material, and this fact explained the results Mr. Rhead obtained in his tests with ferric chloride, as well as the copper enrichments near the edges of the plates. He agreed with Sir Gerard Muntz that these were not deposits of copper, but were spaces where the zinc had been dissolved out.

Mr. Sinclair thought that stray currents through the water pipes and condenser set up electrolysis. He had suggested as a remedy that the whole of the condenser should form a complete electric circuit.

Second Day's Papers.

Prof. T. Turner and Mr. M. Thornton Murray presented a paper on "The Copper-Zinc Alloys" (abstracted elsewhere in the Synopsis in this issue).

The discussion was opened by Mr. Bengough, who considered that as the curve of total shrinkage varied to a great extent for different alloys, and also for different sizes of castings, that curve must prove of very great practical value. Tubular results might, perhaps, have been better for the workshop. He considered that the similarity between the results of the "Brinnel test" and the tensile results quoted in the fourth report of the alloys research committee was worth attention.

Dr. Desch did not think that the authors' paper proved that a real expansion occurred during solidification; indeed, there appeared to be some evidence that there was contraction. Growth of crystals caused a thrust which might account for the apparent expansion, but this was a question of scientific interest only. To the practical brass founder it did not matter whether there were a true expansion or molecular action.

Mr. Vaughan Hughes described the paper as one of the most valuable of its kind which had been produced for some years.

Mr. Rhead suggested that microscopic examination might determine the true nature of the expansion.

Sir William White said that whatever might be the real explanation of the facts stated by the authors, the paper was admittedly one of the most notable which had been published for a long time.

Dr. Rosenhain wrote to say that he had some hesitation in accepting Professor Turner's extensometer readings as regarded changes in volume during solidification. The portion of the paper which dealt with actual observations of expansion constituted a most valuable addition to our knowledge of such alloys.

The next paper, on "The Elastic Breakdown of Non-Ferrous Metals," was presented by Mr. C. A. M. Smith. (It is abstracted in the Synopsis elsewhere in this issue.)

Sir Gerard Muntz led the discussion and commented on Mr. Smith's statement as to the want of uniformity in the specimens. In the case of non-ferrous metals that was one of the greatest difficulties. It was not easy to get concordant results with processes apparently identical. More was known about iron and steel, and with those metals there was not the same difficulty in complying with the stipulated test conditions. Heat treatment and other manufacturing processes gave rise to various questions which were constantly being investigated in their works, and he had also sent specimens of materials to their scientific members with the view of eliciting further knowledge of the effect of various processes on copper.

Mr. Parker gave his opinion that the sphingometer was not necessary nor suitable for commercial work. He preferred the Unwin extensometer. He deprecated the use of wedge grips for holding specimens, and was of opinion that, for round tests, screw nuts and screw grips with spherical seats should be used. He considered that the stress-set and stress-strain curves should accompany research reports. Such curves were of the highest importance to designers of modern high-speed machinery. The best definition of "elastic limit," for engineering work, would probably be the stress per square inch producing a permanent set of 0.001 in. on a 2-in. length.

Sir William White appealed to the members to supply Mr. Smith with materials to enable him to continue his investigations.

Professor Smith, in the course of his reply, admitted that his work had been greatly impeded by want of uniformity in the specimens of copper. As to trouble arising from vibration with the sphingometer, there was no difficulty in making the required corrections where vibration existed, but, of course, if perfect accuracy were desired, vibration must be absent.

Corrosion in Boilers.

The *Journal* of the Society of Chemical Industry recently mentioned a noteworthy case of corrosion in a stand-by boiler at a London power house. The action had been evident for a long time, and continued attempts to stop it by the use of caustic soda were fruitless. Scientific investigations traced its cause to the presence of manganese sulphide in the steel, which sulphide by oxidation had formed sulphuric acid. The acid being behind a film of rust, the corrosion continued, although the boiler water was alkaline. There were many blisters—some having a diameter of 3 cm—on the inside of the boiler, and it was apparent that the oxygen requisite to transform the sulphide into acid diffused through the blisters at a greater rate than the alkali in the water. The addition of sodic arsenite was found to remedy the mischief.

LONDON, October, 1909.

Platinum.—According to the U. S. Geological Survey statistics, platinum is produced in this country only as a by-product in placer-gold mining in Oregon and California. The output in 1908 was 750 troy ounces, valued at $14,250. The yearly importations from Russia during the last three years have ranged from 4,237 lb. to 11,494 lb. ($1,095,754 to $3,601,120).

SYNOPSIS OF PERIODICAL LITERATURE

Iron and Steel.

While a full account of the recent London meeting of the Iron and Steel Institute was given in our last issue, page 487, with abstracts of all the papers presented, we give herewith some additional notes on two particularly interesting papers.

Electric Smelting of Iron Ore.—Mr. E. J. Ljungberg, of Halun, Sweden, described at the recent meeting of the Iron and Steel Institute the new shaft furnace of the Electrometall Company at Donnarfvet, constructed by Messrs. Grönwall & Lindblad (see our June issue, page 250, October, 420 and pages 489, 491 of this issue). The report gives the result of 1093 hours running of this furnace, during which it produced 280 tons of crude iron containing all the way from 3.09 per cent down to 0.95 per cent of carbon. The product with less than 2 per cent of carbon, produced in a liquid state by direct reduction of iron ore, is, indeed, a new commercial product; it is not pig iron, as that term is ordinarily understood. We propose for it the name "*pig steel*" (German, *Rohstahl*" French, "*fonte d'acier*"—*Reviewer*).

In the run described, the consumption of materials and power per metric ton of product was as follows:

Ore	1380 kilos
Lime	86 "
Coke	146 "
Charcoal	207 "
Electrodes, effectively used	9 "
Electrodes, wasted ends	14 "
Power	0.492 hp-year

The escaping gases were low in temperature, carried the steam from the moisture of the charges, and contained 8 per cent to 41 per cent CO^2 and 40 per cent to 61 per cent of CO. They were free from nitrogen. It is calculated that 30 per cent of the whole energy of the current was lost by radiation and in cooling water, and attempts are being made to reduce these losses. The reaction of reduction, according to these analyses, is probably

$$4\,Fe^2O^3 + 9\,C = 6\,CO + 3\,CO^2 + 8\,Fe,$$

which is a better utilization of the carbon than has previously been obtained and which gives promise of the ratio 1 CO to 1 CO^2 (predicted as possible by Prof. J. W. Richards, this journal, June, 1909, page 253) being ultimately attained.

Ljungberg concludes his article by the statement that the problem of the electrical reduction of iron ore can be regarded as "technically solved."

In the discussion, it transpired that the constructors of this furnace have contracted to erect three of large size at Sault Ste. Marie, Canada, which will be in operation about the middle of 1910.

"Growth" of Cast Iron in Heating.—Mr. Outerbridge, of Philadelphia, first studied systematically the phenomenon of cast iron increasing in volume by repeated heatings, and Professors Rugan and Carpenter reported to the Iron and Steel Institute the results of their study of the same subject.

Taking a gray cast iron, no growth was observed at 600°, but this result is faulty, since cast iron valves are known to increase in size at 360° in superheated steam. The heating at 600° was not prolonged sufficiently to get the effect. Two hours' heating at 650° produced a slight expansion, became greater in three hours. At 675° the rate of growth was eight times as rapid as at 650°. Maximum growth was attained by heating three hours at 730°, no greater expansion being obtained at 800°, nor by 17 hours' heating at 730°. After 93 heatings and coolings the cast irons tested (containing 0.96 per cent to 1.13 per cent silicon and 3.14 per cent to 3.48 per cent carbon) increased in volume 3.5 per cent to 3.75 per cent, and at the same time 7.86 per cent to 8.60 per cent in weight. This increase in weight had not been observed by Mr. Outerbridge. The cause of the growth was studied microscopically and found

to be the passage of the gases of the furnace (CO and CO^2) between the plates of graphite and the iron, oxidizing in these slits the silicon in the iron at the boundaries of the crystals, producing growth by the disintegration of the surface of these crystals and their pressure upon the graphite plates. The increase in weight is due to the absorption of oxygen and perhaps also of carbon. On reheating, the gases penetrate further into the metal, because of the avenues opened up by the previous heating. After many heatings the graphite is partly oxidized away, all the iron silicide in solid solution in the iron has been oxidized and disintegrated, and some iron has been oxidized as well. White irons do not thus grow, and where the repeated heatings and coolings tend to destroy cast iron it should be white instead of grey, and will then even shrink slightly on repeated heating if not high in carbon.

That the furnace gases cause the growth was very neatly proved by repeatedly heating some of the specimens in a vacuum when the growth did not take place.

Copper.

Standard Specifications.—In the London Engineering of Sept 17 we find a note on the report of the Copper Committee of the International Congress for Testing Materials, by its president, Prof. Leon Guillet, Paris, entitled "On Standard Specifications for the Purchase of Copper." In it replies were given by members to a number of questions which had been asked with reference to the committee's work and the specifications dealing with the manufacture and inspection of copper. This report gave an abstract of the specifications in force in Great Britain, France, Germany, Austria, Italy and Belgium. In regard to Great Britain, Messrs. Glazebrook and Tomlinson, the British members, stated that the specifications of the Engineering Standards Committee were much appreciated by the trade, and gave satisfaction; no modification appeared to them necessary. Meetings were held annually, in the course of which the question of modification or revision was considered. One Austrian delegate, a copper manufacturer, had remarked that the allowance on thickness and weight up to 3 per cent, which was granted, appeared to be sufficient for all copper material except wide plates, for the manufacture of fire boxes. The largest rolls, 900 mm (35½ in.) and over in diameter, used for rolling wide plates, might occasionally become concave to a slight extent, probably up to ¾ mm (0.029 in.), so that a wide plate might be 1½ mm to 2 mm (0.059 in. to 0.078 in.) thicker in the center than at the sides, and it was at the sides that the plates were measured. Some of the plates, therefore, were heavier than they should be theoretically. The Austrian manufacturers endeavored to obtain an allowance ranging from 3 to 6 per cent for plates ranging in width from 2.3 m (7 ft. 6½ in.) and under up to 3.2 m (10 ft. 6 in.). Another Austrian delegate, an inspector of railways, thought that the purchaser should not be called upon to pay for an unnecessary weight of copper, and the allowance of 3 per cent for wide plates has its advocates. Manufacturers should put down convex rolls for manufacturing such plates.

The question of impurities in copper, and their action in various proportions, was also dealt with; but this point, as well as that concerning the physical tests, had not been entered into with sufficient detail, owing to the short time the committee had at its disposal. It was hoped that a complete agreement would shortly be reached, and that a detailed report on a standard specification for the purchase of copper would be ready for the following Congress.

At a recent meeting of the members forming the Copper Committee, the British members desired to maintain the conditions of the British Standards Specification. Tensile tests for copper were maintained, with a maximum of 22 kg per square millimeter (14 tons per square inch). No final agreement had been reached in regard to elongation, nor in regard to annealing temperature, speed of tensile test, and shape of test-specimen. No final agreement had been reached either in the matter of tests by chemical analyses. The details would be given in a later report.

Zinc.

Technical Assay of Zinc.—In a paper presented at the recent Manchester meeting of the (Brit.) Institute of Metals, Mr. H. W. Greenwood and Dr. F. J. Brislee discussed the relative value and accuracy of the various analytical methods for the determination of zinc and also the gathering together of the more important references to the analytical chemistry of zinc in both British and foreign literature. As a volumetric method they prefer Schaffner's on the grounds of its accuracy, definite nature of endpoint of reaction and general applicability. The gravimetric estimation of zinc is not recommended by them as a technical method, but when necessary they prefer the estimation as pyrophosphate for moderate quantities and a modified calcium zincate method for small quantities. Electrolytic methods are not, in the opinion of the authors, to be recommended for technical work. Good results can be obtained by several methods, but the deposit is difficult to deal with and for that reason volumetric methods have been found much more advantageous. A number of methods for the assay of zinc ores and alloys are dealt with, some of which the authors believe have not hitherto been published, notably a method for the estimation of zinc and aluminium in alloys of these metals, by the weight of hydrogen evolved on solution of the alloy in hydrochloric acid. The authors hope to continue their work on other non-ferrous metals. (From advance sheets.)

Copper-Zinc Alloys—Prof. T. Turner and Mr. M. Thornton Murray presented a paper on the solidification phenomena of copper-zinc alloys at the recent Manchester meeting of the (Brit.) Institute of Metals. For some years past investigations have been in progress in the University of Birmingham on the changes in volume which occur when metals pass from the fluid state to the temperature of the air. Important results have been obtained in the case of cast iron which has been proved to have three definite expansions while the solid metal is cooling, these arrests corresponding to particular temperatures, and the separation of certain ingredients. The experiments have now been continued in a study of the alloys of copper and zinc which, as the brasses, constitute the most important of the industrial alloys. The hitherto unrecorded fact is published that with certain percentage of zinc and copper the metal when poured into the mold does not immediately begin to contract, owing to the cooling, as might be anticipated, but for a short time actually expands. This expansion, no doubt, accounts for the excellent impression of the mold, and the sharp lines, which are met with in certain brass castings. Ore alloys with about 15 per cent of copper expands in a most remarkable manner, so much so indeed that after the metal has finally cooled and shrunk in the mold the bar is as long as the pattern from which it was cast. It is curious to note, however, that some of the alloys in the series do not expand at all when solidifying, these being the brass with 60 per cent of copper, known as Muntz metal, and that with 40 per cent of copper, which is a hard white brittle alloy, and probably a definite chemical compound. The authors have also determined the hardness of these alloys and find that the 40 per cent alloy is the hardest of the series, and that it is actually much harder than mild steel. The experiments are likely to have an important theoretical as well as practical bearing, as it is believed expansometer tests will be more largely used in future as an aid to the determination of the constitution of alloys.

Miscellaneous.

Solders.—At the recent Manchester meeting of the (Brit.) Institute of Metals, Mr. C. O. Bannister and Mr. H. J. Tabor presented a paper containing the results of experiments, carried out with a view to obtain exact information on the effect of small quantities of impurities on the surface appearance of solders. It is well known that sales of solder are often influenced by appearance rather than by analysis, and it is

important that when cast in the form of strips the solder should have a white, bright surface with a furrow and be free from rough patches, spots, pits or pimples. The effect of antimony, which has been previously noted by Parry, is worked out fairly full, the effect of casting under different conditions being noted, in addition to the effect of varying quantities of antimony. The results confirm the statement that tinman's solder containing 2 per cent antimony, 46 per cent tin and 53 per cent lead is superior in appearance to that of the alloy consisting wholly of lead and tin in equal proportions and that with 3 per cent antimony spots appear on the surface.

Microscopic examination of these alloys shows that in the case of the 3 per cent antimony alloy cubical crystals are seen on the prepared sections after polishing and etching. These crystals probably consist of the compound SnSb and are not found in the alloys containing 1 and 2 per cent antimony. The segregation of these crystals to the top of the alloy seems to cause the spots. Solders containing small quantities of copper give good surfaces, but with a tendency to spot, while larger quantities, 0.5 per cent and upward, give dull, flat and crystalline surfaces. Solders containing small quantities of silver have a peculiar white crystalline appearance. Zinc is a most detrimental metal to have present in solders, minute quantities as 0.005 per cent making the surface crystalline, while 0.1 per cent and over give extremely uneven and inferior surface appearances.

Elastic Breakdown of Non-Ferrous Metals.—A paper on this subject was presented by Prof. C. Alfred M. Smith at the recent Manchester meeting of the (Brit.) Institute of Metals. He said that some three years ago he commenced to attack the problem of the cause of elastic breakdown of materials used in engineering work. Various researches and investigations published by him showed that the solution of the problem as regards mild steel was different to that generally accepted by engineers in England and on the Continent. Elastic failure of mild steel always took place, under any system of loading, by reason of the sheer stress. Having proved that, he wished to find out whether all other ductile materials followed the same law. He could only say that they appeared to do so, he could produce no exact experimental evidence. The reason was that copper, aluminium, Muntz metal and various other materials appeared to be much less homogeneous than mild steel. In a word, the result of his researches proved that, so far as the elastic properties of the material were concerned, mild steel was much more reliable than other materials. He produced the results of a large number of tests upon various materials and described in detail the instrument which he has invented for measuring small strains and which is known as the sphingometer. It is an exceedingly simple device and measures extensions of length of the astonishingly small amount of a quarter of a millionth part of an inch. It has been especially useful in testing work and will measure torque strains as well as extensions of length. Among the interesting facts which Professor Smith's experiments reveal are the peculiar fracture of aluminium and the effect of low temperature heat treatment on the non-ferrous metals. (From advance sheets.)

Melting Points.—The *Amer. Jour. of Science* of November contains two papers by W. P. White on work done in the Geophysical Laboratory in Washington on melting-point determinations. The first paper treats of melting phenomena in general. The second paper describes the furnace technic used in melting-point determinations. The results of the first paper are summed up as follows:

Actual melting and freezing point curves are nearly always oblique—that is, they show not the constant temperature called for by elementary theory, but instead, an interval within which the temperature continuously rises or falls. The prime cause of obliquity in melting curves is the obliquity of the melting itself, due to impurity. The true melting point is the high end of the oblique melting interval. The melting hysteresis of some very viscous substances (mostly compounds of boron and silicon) is also an occasional (and then serious) cause of obliquity. A number of causes of obliquity lie in the experimental determination of the behavior of the melting and freezing substance. The determination of a melting curve necessarily involves two factors, temperature rise and heat supply; the latter depends on the temperature difference of furnace and melting charge; if this varies, the curve is distorted in a way striking but easy to correct. The most common and conspicuous example is where the furnace temperature is allowed to rise or fall continuously, while the substance, melting or freezing, remains nearly stationary. The freezing point, coming at the beginning (in time) of the interval, where temperature distribution in the charge is relatively uniform, is easier to observe than the melting point, but is inadmissible to substances where undercooling is marked. The melting point coming at the end (in time) of the interval, is liable, where stirring is not practiced, to obliquities resulting from uneven temperature distribution. First, due to the inevitable temperature difference between inside and outside of the charge, troublesome with large charges, negligible with small. Second, due to various irregularities in heat flow, less with narrow charges and small thermoelements, hardly ever over a degree or two. Third, due to conduction of heat down the thermoelement, also less with narrow charges and small thermoelements, for which it is usually negligible, but possibly amounting to several degrees with inclosed elements. Electric conductivity in the melt produces an error in the reading of bare thermoelements, thus far negligible in small charges of salts. Contaminated elements, besides reading false, read so as to increase obliquity. Differentiation and diathermancy of the charge probably increase obliquity. Meltings have been made above 800° agreeing with each other to 0.05°. In most cases an experimental obliquity remains of from 0.5 to 1.5° (at high temperatures).

In the second paper the author gives a description of the furnace, crucibles, thermoelements used in melting-point determinations and then deals with some particular methods for the determination of melting points, melting points of viscous substances, quasi-calorimetric determinations, small thermal effects, and residual meltings. The results are summed up as follows. Platinum-resistance furnaces of simple construction provide complete control of the temperature for melting-point work up to 1600° C. Where uniformity of temperature throughout the working chamber is important special modifications are necessary. Small charges (2.5 grams) give very sharp melting points, are economical of material, and permit of convenient manipulation. A number of advantages result from the use of a second thermoelement, which is made to give directly the furnace temperature about the charge. The measurement and regulation of the heat supply from the furnace are factors of great importance in accurate melting point determination. Methods of heating and insulating thermoelements and of avoiding the effects of contamination have been developed by the author, suited to various conditions and kinds of work. The melting points of very viscous substances, showing hysteresis, can be determined easily and effectively by very slow heating and occasional examination outside the furnace. The approximate determination of latent heats of fusion directly from melting curves is possible by measurements of the furnace temperature, but is complicated by several hitherto undetermined sources of error. The attainment of an accuracy greater than 10 per cent (about 10 calories in many cases) accordingly requires special apparatus and procedure. The smaller latent heats of inversion can usually be determined to one or two calories with much simpler apparatus than the two thermoelements. For deteriorating fusion or sluggish thermal effects rapid rates of heating and the utmost precision in furnace regulation and temperature measurement are needed. The accurate location of eutectics by thermal means requires the detection of small residues of the component in excess.

RECENT METALLURGICAL AND ELECTROCHEMICAL PATENTS

Iron and Steel.

Dry Blast.—The dry-blast process of Mr James Gayley has undoubtedly been the most important advance in the metallurgy of iron in recent years. Though it has at once yielded savings, far beyond what had been expected or what had been thought by many to be possible, it is still being improved and perfected by its ingenious inventor. The dry-blast systems which have been installed in plants previously constructed were so arranged that the blowing engines were in proximity to the blast furnaces, while the refrigerating apparatus or dry-air plant has been placed at considerable distance from the blowing engines, owing to its size, and the filling of the space near the furnace by various other buildings appurtenant to the furnace. In these plants, therefore, a long pipe or conduit extends from the air-drying apparatus to the blowing engines, and it has not been recognized in the past that any disadvantage resulted. Mr. Gayley has found, however, that this long pipe causes a considerable variation in the weight of the air fed to the blowing engines. These pipes or conduits have been made of comparatively thin sheet iron or steel, and as they are subjected to the heating rays of the sun by day and to air of a cooler temperature at night, the air passing through them reached the blowing engine at varying temperatures, and consequently varying weights per unit of volume. On the other hand, it is easy to see that the air should not only have a substantially uniform moisture content, but should be of substantially uniform temperature, as it enters the blowing engine, in order that the blowing engine, and consequently the blast furnace or converter shall receive a supply of air which is not only uniform as regards its moisture content, but also uniform as to weight. The air is, of course, measured by the blowing engine as it passes through the blowing engine, and unless the air received by the blowing engine is uniform in temperature the blowing engine will deliver non-uniform weights of air, and consequently the metallurgical process will not be uniform. The blowing engine can only measure the air as to volume, while uniformity as to content of moisture, and as to weight, can only be obtained by treatment of the air before it is supplied to the blowing engine. In carrying out this discovery when dry-air apparatus is applied to existing plants, where the air-drying apparatus is remote from the blowing engine, Mr. Gayley therefore now proposes to jacket or otherwise protect the air conduit to the blowing engine in order to preserve a substantially uniform temperature of the air therein, and thus supply air of substantially uniform weight, as well as substantially uniform moisture content, to the blowing engine. (935,628, Sept. 28, 1909.)

Thermit Process.—In the well-known aluminothermic process for the welding of metals and similar uses thermit, which consists of a mixture of finely divided aluminium and ferric oxide, is employed. The reaction between the metal and oxide results in the reduction of the iron oxide and the oxidation of the aluminium. The heat generated by this reaction is very great and has found useful application in a number of ways. It has been tried to use silicon as a substitute for aluminium in this reaction according to the equation $3\,Si + 2\,Fe_2O_3 = 4\,Fe + 3\,SiO_2$, but the reaction has been stated to be too slow for practical applications. Mr. Frank J. Tone, of the Carborundum Company (who has reduced the production of metallic silicon to a commercial process on the large scale) claims, however, now that a mixture of silicon and oxygen compounds is capable of the self-propagating reaction which distinguishes the aluminothermic process. He uses a mixture "of finely divided metallic silicon and some oxide, as, for instance, ferric oxide, preferably in the proportion of 84 parts of silicon and 320 parts of ferric oxide." Ignition is obtained by the use of a small quantity of one of the unstable compounds, such as potassium chlorate or sodium peroxide, mixed with part of the silicon. The mixture of silicon with these unstable oxides may be ignited with a match. (939,930, Nov. 9, 1909.)

In a second patent of the same inventor this process is modified in order to increase the energy density. If a mixture is made of silicon and a "highly oxidized unstable oxygen compound," like potassium chlorate $3\,Si + 2\,KClO_3 = 3\,SiO_2 + 2\,KCl$, the reaction is so violent as to be almost explosive in character, and one which cannot be made use of in practical work. But by replacing only a part of the ferric oxide with "a highly oxidized" oxygen compound, there is no explosion or tendency of the mixture to be thrown out of the containing vessel, and the energy density of the mass is greatly increased In practice, Mr. Tone has found that by taking one part of a mixture of silicon and potassium chlorate made up in accordance with the last equation and three parts of a mixture of silicon and ferric oxide made up in accordance with the equation $3\,Si + 2\,Fe_2O_3 = 4\,Fe + 3\,SiO_2$ he gets very satisfactory results. The reaction, after being initiated, proceeds without violence and "the heat generated is more intense." (939,570, Nov. 9, 1909.)

Calcium-Silicon Alloy for Steel Refining.—The calcium-silicon alloy is an excellent refining agent for steel. Dr. Hans Goldschmidt, who has paid much attention to this alloy (see his article in our Vol. VI, page 244), had recently patented a process of making such an alloy, which was described in our June issue, page 284. This alloy contains about one-third of calcium and two-thirds of silicon. To enrich this alloy much more in silicon, Dr. Hans Goldschmidt and Dr. O. Weil now propose the following process: They melt the alloy down with iron under a protecting layer of chloride of calcium, whereby the iron, under formation of ferrosilicon, combines with such a quantity of silicon that an alloy will be formed containing about two-thirds of calcium and one-third of silicon. This alloy is of less specific weight than the ferrosilicon, so that the latter sinks down to the bottom and may be easily separated. A good result is obtained by employing 1 kg of calcium-silicon alloy and 1 kg to 2 kg of iron. In the same way the alloys of other alkaline earth metals with silicon may be enriched by melting them together with iron. (938,758, Nov. 2, 1909.)

Titanium-Silicon-Carbon Ferro.—For steel refining Mr. Fred. M. Becket recommends the use of an alloy containing chiefly titanium, iron, silica and carbon. A typical analysis is: titanium, 33.70 per cent; iron, 43.69; silicon, 14.23; carbon, 8.32; aluminium, 0.08; calcium, trace. The alloy in a suitable state of subdivision is added to the molten metal at the time of casting. The titanium is believed to act chiefly upon the occluded nitrogen and the silicon upon the hydrogen and dissolved oxides. The alloy is prepared in the electric furnace by either of the following methods: (1) by reducing by carbon in an electric furnace a charge containing oxides of titanium and silicon; (2) by reducing oxide of titanium by carbon in an electric furnace, ferrosilicon or silicon being incorporated with the charge or added to the bath. The carbon is usually employed in substantially the proportion required to unite with the oxygen of the oxides of the charge. The process is rendered continuous by adding fresh portions of the charge and removing the products from time to time. The patent is assigned to the Electro Metallurgical Company. (940,665, Nov. 23, 1909.)

Reduction of Carbon in Castings.—Mr. W. Rübel patents a process for quickly reducing the carbon content in pig iron for use for small castings and states that a modification of the process may be employed to reduce the carbon content in finished castings, without the necessity of annealing afterward. The process depends on treatment of the molten pig iron with fused sodium hydroxide (melting point, 750° C.). When the molten pig iron, containing about 3.5 per cent of carbon, meets the molten sodium hydroxide, double decomposition takes place, in the course of which the sodium hydroxide is transformed into carbonate of sodium, thereby withdrawing the carbon from the

iron. In this reaction hydrogen is liberated and is burned. The high degree of heat so generated aids the formation of pearlite. If finished castings containing 3.5 per cent C. are to be treated they are put into a retort or a muffle containing fused sodium hydroxide or potassium hydroxide, in such quantity that the castings are completely covered by the molten hydroxide. The temperature of the retort or muffle is then raised to 1100° C. or 1500° C., and, at this temperature, decarburization proceeds very rapidly. The retort or muffle is provided with a safety valve capable of withstanding a pressure of about two atmospheres. If the gas pressure in the retort exceeds that amount, the valve opens and the gas passes through a cooling coil into a receptacle filled with a solution of ammonia, whereby the sodium liberated in the process is dissolved. The gases not absorbed by the ammonia are carried back to the furnace and serve to heat the same. It is important to obtain a pressure of about two atmospheres, as this promotes the reaction. If, for example, the decarburization is to be carried out to the extent of reducing 3.5 per cent to about 1.5 per cent, at the temperatures given, heating for about two hours is required. At the end of this time a valve provided on the retort or muffle is opened and the excess of sodium hydroxide is run off. Then the retort is permitted to cool gradually and the castings are removed. For the complete decarburization of castings up to about 20 mm thickness, about six hours is required. "Iron decarburized by the above method has a crystalline lustrous fracture like ingot-iron cast from crucibles. By changing the time and temperatures employed decarburization may be so regulated that the finished product, after annealing, is equal to fine casting in steel of corresponding quality." (935,234, Sept. 28.)

Deoxidizing Slags.—Aluminium has long been known to be an excellent deoxidizing agent for use in steel refining. Only small quantities are used, however, in each case, because the aluminium burns with the oxygen in the steel bath to form a slag which is separated with difficulty. If, however, the aluminium is passed through the metal after the oxides have been extracted, there is no formation of clay, and the aluminium, if properly introduced, ascends to the surface of the metal and acts upon the layer of slag from below. This method is employed by Mr. O. Thallner for the deoxidation of the slag. Quantities of aluminium are introduced into the metal bath below the slag at intervals; they are in excess of that required to deoxidize the metal. In this way a sufficient quantity of aluminium eventually rises to the top of the metal and burns in its course through the slag, thereby deoxidizing the slag. The aluminium rising through the deoxidized steel to the surface of the metal bath, spreads in a layer between this metal bath and then rises through the slag, so that the deoxidation proceeds from below. The completion of the deoxidation is indicated by the white color of the slag. "This white slag is well adapted to allow the passage therethrough of sulphur. This last feature is one of considerable importance, as the molten bath of steel can be freed of its content of sulphur subsequent to the deoxidation." (936,382, Oct. 12, 1909.)

Permanent Magnet Steel.—Mr. S. E. Gertler patents a steel for permanent magnets, comprising tungsten 5.25 per cent, carbon 0.65 per cent, silicon 0.15 per cent, manganese 0.25 per cent, chromium 0.20 per cent, sulphur and phosphorus 0.02 per cent or less, aluminium 2.50 per cent, and iron to an amount providing 100 per cent in all. (936,530, Oct. 12.)

Electric Steel Furnace.—The well-known modified induction furnace of Messrs. Hermann Rochling and Wilhelm Rodenhauser has been so often described in detail in this journal that a brief reference to the patent which has just been granted to the inventors for this furnace must suffice here. (939,095, Nov. 2, 1909.)

Iron-Ore Reduction Furnace.—Elsewhere in this issue will be found an American Electrochemical Society paper by Mr. Edward R. Taylor (the inventor of the electric carbon-bisulphide furnace, which is in successful operation on a large scale as well known to our readers). This paper contains an illustrated description of his new electric furnace for the reduction of iron ore. Two patents have just been granted to Mr. Taylor for this furnace, one, the process patent has 26 claims; the other, the apparatus patent, has 60 claims. (938,352 and 938,351, Oct. 26.)

Aluminium and Iron.—The abstract of a recent patent of Mr. A. G. Betts, which will be found below under Aluminium, should be interesting to iron metallurgists.

Aluminium.

Production of Aluminium.—Only one process, that of Hall & Heroult, is used the world over for the production of aluminium and has been very successful, in spite of the recent slump in the market price. That there is, however, much space for a cheaper process, starting from cheaper raw materials, there can be no doubt. Mr. Anson G. Betts proposes the following. Iron ore and aluminium ore, e.g., bauxite or kaolin, are charged with fuel in a blast furnace similar to an iron blast furnace, differing from it, however, in action, in that a higher temperature is used in the smelting section of the furnace. The higher temperature may be produced by using a more highly heated blast, but especially well by blowing the furnace with air, from which some of the nitrogen has been removed; such a gaseous mixture may be produced by liquefaction and fractionation of air. In an iron furnace little or no aluminium is reduced with the iron, but a fair amount of silicon is formed. In smelting for iron-aluminium alloys practically all the silicon present is reduced; and as silica is always a constituent of both iron and aluminium ores, the product is not ferro-aluminium, but iron aluminium-silicon. The most readily oxidized, sulphurized, chloridized, etc., metal of the iron-aluminium-silicon, aluminium may be removed as pure aluminium compound by treatment with suitable oxidizing, sulphurizing and chloridizing reagents. Thus treatment of iron-aluminium-silicon with silica at high temperatures gives a slag of pure alumina and ferrosilicon.

$$Fe_xSi_yAl_z + 3\,SiO_2 = Fe_xSi_{y+3} + 2\,Al_2O_3$$

or treatment of iron-aluminium-silicon with iron ore gives, at high temperatures, pure fused alumina and ferrosilicon, provided the iron ore is free from lime, magnesia, etc.

The aluminium alloy is then treated with iron sulphide, both being used in fused condition directly after tapping from their respective smelting furnaces, giving the reaction

$$2\,Al + 3\,FeS = Al_2S_3 + 3\,Fe$$

"The aluminum sulphide is more readily and cheaply reduced to aluminium than the oxide is" and iron sulphide is available in large quantities, permitting the recovery of both iron and sulphur. Although iron sulphide is available in a fairly pure condition, Mr. Betts prefers to run the sulphide through a furnace with suitable additions to flux off the gangue, for the double purpose of getting rid of the gangue and for heating the sulphide. When pyrite is smelted, he contemplates being able to increase the yield of sulphide by adding iron oxide to the charge to carry out these reactions

$$FeS_2 = FeS + S$$

$$FeO + S + CO = FeS + CO_2.$$

That is to say, the first reaction is the decomposition of the pyrites by heat into ferrous sulphide and sulphur. The liberated sulphur acting on iron oxide in presence of carbon or carbon monoxide produces a further quantity of iron sulphide.

In smelting the aluminium alloy with the sulphide, the aluminium is used in excess so that the end products of the reaction are aluminium sulphide, substantially free from the sulphides of more readily reducible metals, and an alloy still containing some aluminium, whose aluminium may be removed readily by oxidizing agents if desired. To insure the reaction taking place so as to be as complete as possible, it is preferred to carry out the reaction in two stages. The alloy that treated

with an insufficient quantity of iron sulphide, etc., to react with the aluminium present, resulting in practically pure aluminium sulphide.

The alloy which will still contain considerable aluminium is then treated with excess of iron sulphide, forming a matte containing both iron and aluminium sulphide, which matte is then used alone or together with fresh iron sulphide in the next treatment of aluminium alloy. Finally, the aluminium sulphide is reduced by electrolysis into aluminium and sulphur. (938,634, Nov. 2, 1909.)

Precious Metals.

Electro-Cyanide Amalgamation Process.—A process, patented by Mr. John R. Parks, of Spokane, Wash., proceeds as follows:

The properly finely powdered ore is delivered to a launder where it meets the cyanide solution and is conducted into the first electro-cyanide pan of a series of tandem pans with gradually increasing levels, so that the contents of each pan will overflow into the next succeeding pan. The inventor allows, "according to the composition of the ore, from ½ lb. to 20 lb. of cyanide of potassium, 5 lb. to 7 lb. of common salt, 1 lb. to 3 lb. of lime, and 1 ton of water to pass into the first cyanide pan with each dry ton of powdered ore. To this is added from 3 oz. to 500 oz. of mercury." After the crushed or powdered ore enters the first pan of the tandem series, each pan holding approximately from 5 tons to 7½ tons of dry ore, it passes from pan to pan of the series, every portion of it undergoing treatment for an average time of from 8 to 12 hours, according to the rate of feed into the first pan. Each of the tandem pans is provided with a horizontal revolving cast-iron disk formed of two or more annular sections and mounted upon insulated bearings, whereby the disk may be used as the anode in an electrolytic circuit. Immediately below the lower face of this revolving disk is a copper plate, which forms the cathode, upon which is deposited the free metal from the solution. Upon this cathode plate is also deposited all of the amalgam metal which forms within the mixture and which, owing to the circulation of the pulped ore, may come into contact with the copper plate.

In order to aid in the chemical action a strong current of compressed air is admitted into the pulped mass as it is forced outward between the two electrodes by paddles upon the revolving disks. This current of air furnishes free oxygen to the solution, as well as assisting greatly in the agitation. In making a complete clean-up of the whole series of tandem pans it is not necessary to interfere with the continuous operation of the mill, since by the use of a bridging launder, which carries the pulp past the pan being cleaned, five of the pans may be constantly in operation. After the ore relieved of its precious metal burden leaves the last of the series of the electro-cyanide pans it is conducted by means of gravity through a launder to the settler or amalgam trap, where the pulp is slightly agitated, so that the particles of heavy amalgam, which have been carried in suspension throughout the entire train of tanks, may here have an opportunity of settling. From the upper part of this tank the waste pulp flows through a launder to the settling tanks from the base of which it is drawn off and allowed to run outside of the mill as waste product.

As the result of his work the inventor says he has found in practice that he is "able to extract from gold ores, silver ores, and gold and silver ores, ranging in values from 4 oz. to 120 oz. of silver per ton and in gold from 1/5 of an oz. to 1¼ oz. per ton. He has extracted and saved from 60 per cent to 90 per cent of the silver values and from 80 per cent to 97.5 per cent of the gold values in the ores, with a total loss of cyanide, including that portion destroyed by chemical action on impurities in the ores and that portion which remains in solution in the moisture of the settled tailings, varying from 0.55 of a pound for ordinary ores to 7.2 lb. for the high-grade refractory silver ores for each ton of ore treated." (940,821, Nov. 23, 1909.)

Copper.

Separation of Copper and Nickel.—The object of a patent of Dr. H. L. Wells is the direct extraction of copper and nickel from a rich matte. The matte containing nickel and copper sulphide is subjected to the action of a heated hydrochloric acid solution. By agitating a matte containing in the neighborhood of 40 per cent each of nickel and copper, with the amount of hydrochloric acid solution required by calculation to convert the nickel into nickel chloride and heated to about 180° Fahr., a large portion of the nickel contained in the matte will be removed in two or three hours. At the expiration of that time the heated hydrochloric acid solution has been converted into a nickeliferous solution containing some unconverted or free hydrochloric acid and the matte into a cupriferous residue containing some nickel. For the conversion of all the hydrochloric acid into nickel chloride, the inventor treats the nickeliferous solution so derived with matte, either fresh or its solid derivatives until all the free acid has been converted into nickel chloride. Further, for the extraction of all the nickel from the cupriferous solid residue, he treats the same with heated hydrochloric acid solution, either fresh or its liquid derivatives, until all of the nickel in the initial charge of matte has been extracted. The solid and liquid derivatives just referred to are intermediate products obtained in the progress of the process and consist, on the one hand, of matte from which the nickel has been partially extracted, and on the other hand, liquid which has been partially exhausted of its free acid.

As the strength of the solution in free acid determines its rapidity of action, and as the richness of the solid residue in nickel determines its rapidity of action, it follows that the most advantageous results can be secured by simultaneously treating two or more charges consisting of matte and its progressively exhausted derivatives with two or more given amounts of hydrochloric acid solution and its progressively exhausted liquid derivatives. The progressive feature of the process is summarized by the statement that the matte is treated successively with three or more solutions, the first of which it finishes and the last of which is fresh acid which finishes it; while at the same time, the liquid starting as fresh acid acts upon three or more solids in the other direction, meeting the fresh matte at the last step and being finished by it. The end products are a nickel chloride solution, on the one hand, in which there is no free acid or practically none, and, on the other hand, a cupriferous residue in which there is no nickel or practically none. The nickel chloride is treated for nickel and hydrochloric acid, which may used again for the treatment of matte. One of two processes, described for this purpose, is as follows: When the nickel chloride solution is evaporated to dryness and the residual solid nickel chloride is heated to a temperature approaching low redness in an atmosphere containing hydrogen, for example, in water-gas, the nickel chloride is changed to metallic nickel, which is left in a pulverulent condition, while hydrochloric acid goes off and may be absorbed by water. (940,292, Nov. 16, 1909.)

Graphite.

Graphite Electrodes.—Mr. A. M. Williamson patents a process for reducing the porosity and increasing the electrical conductivity of artificial graphite, electrodes, etc., made in the electric furnace. The patent is assigned to the International Acheson Graphite Company. These results are accomplished, without introducing into the completed article any extraneous material by impregnating the articles to be graphitized with a material which is itself capable of transformation into graphite, or which yields a residue capable of such transformation. The carbon electrodes or other articles, after having been molded and baked to drive off the volatile matter, are impregnated with coal-tar pitch, coal tar or molasses, etc. By the use of vacuum or pressure the impregnation may be improved. (935,180, Sept. 28, 1909.)

Reduction of Losses in Gold Recovery.

The following is a description of the Pierce gold separator and amalgamator, which has proven very successful during the past few years in various mills in Colorado, Idaho and elsewhere in decreasing the loss of gold. We will first describe the application of the Pierce machine to placer mining.

In the flume, or at the end of it, is set a section of flume, and in its bottom are placed one or more sets of V-shaped grizzleys, the bars of which are at a slight angle from the flow of the water so that the fine gold, sand and gravel is gradually brought to the openings, and passes through them into the grizzley box, supported by rods underneath the grizzley and flume. Its bottom slants downward with the flow of the water, and at the lower end there is a gate that can be regulated so as to take from the flume only as much water as is necessary to

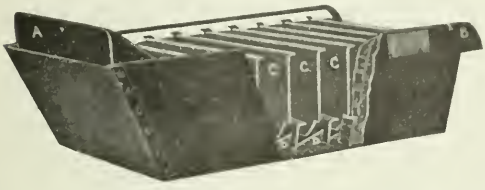


FIG. 1.—PIERCE AMALGAMATOR

carry or move the gold, sand and gravel that pass through the grizzleys.

The gold, sand and gravel are then taken to the screen boxes, where the coarse gold and gravel are separated from the fine gold and sand, the latter passing through the screens. These are adjusted so that the end of the screen that the gravel passes over is higher than where it comes on the screen. Underneath the screen is a gate which is adjusted so as to take only the amount of water and sand that is required for the amalgamating boxes and riffles. Thus the water is kept over the screens and expels the air from underneath it, and the flow of the water carries the fine gravel and coarse gold over it. There is, therefore, no tendency to clog the meshes of the screen.

The fine gold and sand passing through the screen are then run through the amalgamated copper riffles. The riffle box (Fig. 1), made of iron, is set at an angle of from 2 in. or 4 in. to 1 ft., according to the material desired to be run through.

The lower riffles *D* are bent something like the letter *Z*. At the top the copper is bent back with a flow of the water and forms an air space, the bottom or *L* of the riffles is turned up at each end and brazed, so as to hold quicksilver in the bottom of each riffle.

The upper riffles *C*, which are made of wood or copper, are held in place by their holders which set on top of the holders holding the under riffles, and are placed above and extending down between the top of the lower riffles, the tops of which are bent back with the flow of water so as to give them strength, while the bottom is bent toward the flow of the water and so constructed as to hold the quicksilver in the bend, or *L*.

All gold, sand and water is then passed through the riffle boxes underneath the upper riffles *C* and over the under riffles *D*. As it passes into the riffle box at *A* it fills it to the top of the first upper riffle, and then passes under it, into the first lower riffle and then up between the first and second upper riffles and to the top of them (where it looks like muddy water boiling), then passes down between the next lower riffles, and then up between the second and third upper riffles, and so on between all the riffles to the lower end of the box. In this zig zag way the gold adheres to the riffles, also sinking in the quicksilver, and the sand and water are thrown out of it at *B*.

The water passing down between the lower riffles throws the black sand out and keeps it agitated, and by keeping it in the flow of the water the fine or "flour" gold is swept against the amalgamated coppers or riffles so many times that it is impossible for it to escape.

The coarse gold as it passes over the bodies of quicksilver exposed in the bottom of each of the upper and lower riffles, though it be tarnished, will readily sink into it (as the specific gravity of gold is 19.4 while that of quicksilver is 13.6) thereby saving all of the gold which passes over the ordinary riffles and mill plates.

The coarse gold and fine gravel that has passed over the screen is then run over iron riffles placed in an iron box. The gold is caught in the quicksilver held in the riffles.

If there are values contained in the black sand it can be concentrated as in mills. By this machine placer mining is reduced to a milling proposition, as the sands are separated, and then the gold is amalgamated in the riffles as in mills, and are ready for the concentrator to save the black sands when they contain values.

In cold countries, there is placed underneath the riffle box a flat top heating tank to hold hot water or steam for the purpose of warming the mercury and water.

In placers where there is clay the machine is set at the head of the flume, with openings in the grizzleys large enough to let all nuggets through so as to get them out of the flume and separated from the clay, to prevent them from being carried out of the flume by it, and they are then treated similarly to that described above.

The same machine may also be used for dredges, where it is set in a flume over the boat, and the separation is made by the grizzleys and screens, thus doing away with the revolving screens.

For the use in mills, the riffles are made the same as those in the placer machine, but smaller, occupying only from 2 sq. ft. to 8 sq. ft. of space, and have from 11 ft. to 14 ft. of amalgamating surface in length. They are made to handle any number of tons crushed in a battery or a mill, and are suitable for any mill, as there is no splash required as for plates. They are set below the mill in place of plates.

These riffles will catch the fine or "flour" gold that passes over plates and concentrators in the slimes; also the heavy tarnished or "rusty" gold that passes over plates which will not amalgamate, but is held in the quicksilver in the riffles.

The riffles can also be used to great advantage in cyanide mills by running the pulp through them and saving the free gold before it goes to the tanks. After the tarnished gold has

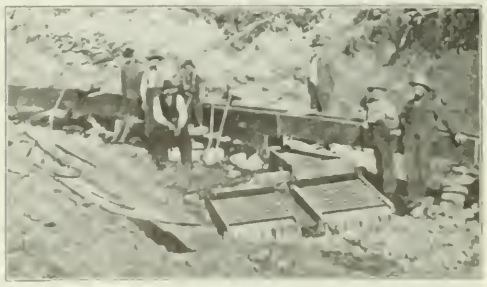


FIG. 2.—AMALGAMATOR AT WORK.

been freed in the tanks by cyanide or other chemicals, it is passed through a finer set of riffles so as to amalgamate the gold freed, thus saving much of the chemicals by not dissolving the gold and conserving tankage capacity. Or the riffles can be set below the tanks so as to pass all of the pulp through them, thus catching any gold escaping by not being dissolved.

This machine is being built under patent No. 906,750 by Mr. I. S. Pierce, [illegible], Oregon, Colo., and is the [illegible] United States.

Hot Blast Stove.

The adjoining illustrations show the Amsler improved hot-blast stove, which is of the three-phase central-combustion chamber type, and is an improvement on the original Massicks & Crooks stove, an English invention. The English design did not find any general acceptance by the American furnace people, as it was deficient in one very vital particular, and that is the matter of providing for expansion and contraction. A hot-blast stove by its nature is constantly either being heated or is being cooled, and the expansion and contraction of the masonry is a very considerable amount in a wall 75 ft. to 100 ft. high. The English design provided that all the masonry be bonded together, and the dome was provided with flues through it longitudinally, connecting the outer or third pass with the chimney.

This design was improved upon by the American agents, Messrs. McClure & Amsler. The improvements consist mainly in separating the three cylindrical vertical walls that form the passes and using a separate crown on the intermediate and the outer walls, the space between being used to connect the last pass with the chimney. This overcame the principal troubles of breaking and crumbling brickwork on account of the uneven expansion and contraction, and it is in this shape that the stove

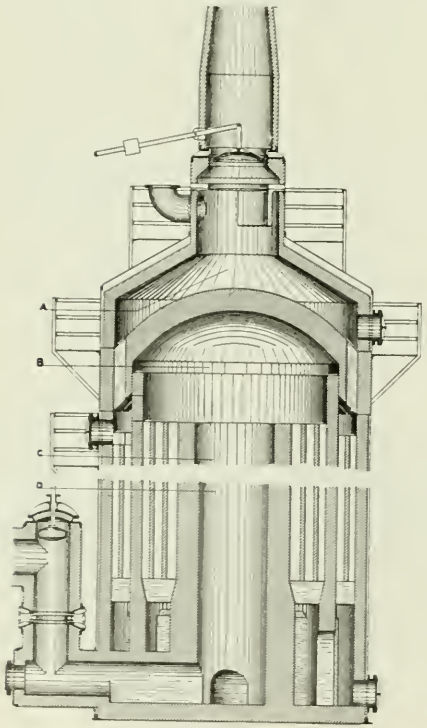


FIG. 1.—VERTICAL SECTION OF HOT-BLAST STOVE.

is being used at present, and finds acceptance in all important installations. The United States Steel Corporation have adopted it and use no other, which bears testimony as to its economy and length of life.

The Amsler improved hot-blast stove is shown in Fig. 1 in vertical section and in Fig. 2 in horizontal section. This design is a further refinement of the original and present stove of this type. It consists of the usual steel air-tight shell lined with firebrick, and provided with the customary cold blast, and gas inlets, and hot blast and chimney outlets, cleaning doors, etc.

The masonry is arranged in three vertical cylindrical walls entirely independent of each other. The two inner ones are open at the top, but the other one is provided with a double dome with vertical flues connecting the outer pass with the space between the domes, and which communicates with the chimney. The intermediate wall is extended up to make a slip joint with a recess provided in the lower dome. The checker work in the passes is built independently of the walls, but is very substan

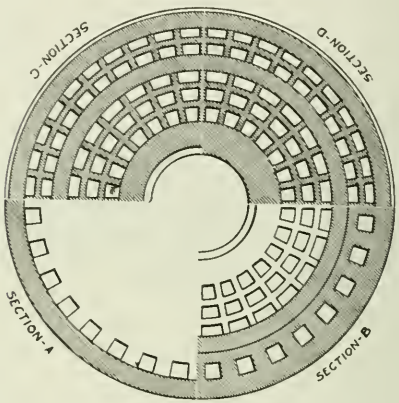


FIG. 2.—HORIZONTAL SECTION OF HOT-BLAST STOVE.

tially bound together. This construction allows of several important improvements. The intermediate wall, having no weight but its own to carry, is made lighter and permits of increased heating surface per stove. The thrust of the lower dome is taken on the plate work and is not transmitted through a checker-work slip joint as in the previous design, and prevents the crumbling of the brick at this point. Another very important feature is that it is possible to use standard 9-in. brick shapes in the stove to a greater extent than heretofore, which has an important bearing on the cost.

There are provided at the base of the stove in the space where the second and the third pass communicate radial walls which extend up to the bottom of the checker work. These prevent the third pass from forming hot flues and producing the trouble known as "hot sides," by equally distributing the gases from the second pass to the third.

Another detail of the improvements is the cold-blast inlet. This is directly under the chimney valve and is so arranged that the entering air strikes a cast-iron baffle plate at a tangent. This takes up the force of the blast and prevents erosion of the masonry.

There are at present three of these stoves, 18 ft. x 75 ft., successfully operating a furnace, 17 ft. x 75 ft., at the Jackson Iron & Steel Company, of Jackson, Ohio. This plant has been in operation for two years and is giving entire satisfaction. A similar plant is under erection for the Bessie Ferro-Silicon Company, of New Straitsville, Ohio.

Dr. Walter O. Amsler, of Pittsburgh, Pa., the designer and patentee of this stove, is a son of the late Carl Amsler, one of the pioneer metallurgical engineers of the steel industries.

Copper Production in 1908.—According to statistical figures of the Geological Survey the production of copper in the Central States, which had a value of $43,553,466 in 1907, amounted to only $29,473,844 in 1908, a decrease of more than 32 per cent. These figures are taken from a report of B. S. Butler and C. E. Siebenthal, which covers Arkansas, Illinois, Iowa, Kansas, Kentucky, Michigan, Oklahoma and Wisconsin.

Production of Gold and Silver in the United States in 1908.

The U. S. Geological Survey and the Bureau of the Mint, acting in co-operation in the examination and analysis of reports for private refineries and records of Federal mints and assay offices, have determined the finished product from domestic mines in 1908 to have been as given below.

The product of gold was 4,574,340 fine ounces, valued at $94,560,000, and the production of silver was 52,440,800 fine ounces, with the commercial value (at the average price of silver for the year) of $28,050,600.

As compared with the figures for 1907 the above shows an increase in the gold product of $4,124,300, and a decrease in in the silver product of 4,073,900 fine ounces. Of the 23 States and Territories producing gold 9 show an increase of production, while 14 show a decrease. Of the 26 States and Territories producing silver, 13 show an increase and 13 a decrease.

Nickel and Cobalt.

From a report by FRANK L. HESS, of the United States Geological Survey (advance chapter from Mineral Resources of the United States for 1908) we take the following summary:

Nickel and cobalt are not produced in large quantities in the United States from domestic ores, the domestic output of nickel in 1908 coming from only two or three places and that of cobalt from only one. Both metals are produced by a lead company, at Fredericktown, Mo., and some nickel ore was shipped from Bunkerville, Nev. Other nickel deposits are known in various parts of the country, but no work of importance was done on them during 1908.

Some nickel salts were made at a New Jersey refinery from electrolytic solutions obtained in the refining of copper. "In copper refining by electrolysis nickel contained in the raw copper anodes goes into solution in the electrolyte, and unless the solutions are changed before the amount of nickel reaches 1 per cent of the solution, nickel is deposited with the copper. It is said that this causes the copper to lose some of its toughness. Before this factor in electrolytic refining was found to be serious it was impossible to make electrolytic copper equal to the best Lake Superior brands, but the refiners say that since the discovery they can make electrolytic copper equal to any other, and even superior to some in electric conductivity."

Some information is given on Monel metal, a copper-nickel alloy, about which an exhaustive article by Mr D. H Browne was published in our March, 1909, issue, page 114.

Cobalt occurs at many places in the United States, but all of the 1908 output came from Fredericktown, Mo., where it is produced in connection with nickel and copper from concentrates obtained in mining for lead

The principal present uses of cobalt are in making glass and pottery. Cobalt oxide imparts a beautiful blue color to glass Some salts of cobalt change in color on absorbing water, being blue when dry, but pink when damp. A familiar hygrometer making use of this property is a doll whose dress is blue in dry weather and pink in damp weather

The supply of nickel for the United States comes almost wholly from the deposits at Sudbury, Ont., Canada. In 1908 the imports for consumption had a total value of $2,497,585, in 1907 the value was $2,243,026. The United States refines much more nickel than it can use, so that, though not a producer, it is a large exporter. The exports in 1908 were 9,770,248 lb., valued at $3,207,988, against 8,772,578 lb., valued at $2,845,663 in 1907.

Large quantities of cobalt minerals are contained in the silver ore at Cobalt, Ont., and the greater part of the cobalt used in the United States comes from that locality The imports for consumption in 1908 were 219,008 lb., valued at $17,077

A Fly-Wheel Repair in the Wilderness.

The largest fly wheel repair ever attempted by means of the thermit process was accomplished some time ago at Sylva, N. C., for the Consolidated Nickel Company, under conditions which offered the greatest difficulties.

Sylva is a little town in the wilderness offering absolutely no facilities for a repair job of any magnitude, and the difficulty of handling a fly wheel segment 24 ft in diameter and weighing approximately 10 tons can be imagined.

The wheel proper consisted of a combination of two pulleys mounted side by side on the same shaft. Each of these pulleys

FIG. 1.—VIEW OF FLYWHEEL.

was made in two parts which were shipped on flat cars to Sylva. One of these parts had to be removed from the car, leveled up on the ground and welded in three places by the thermit process. There were two fractures on one of the spokes and a fracture directly across the rim, as shown in the illustrations.

All materials for the work were shipped from New York, and engineers of the Goldschmidt Thermit Company were sent to Sylva to superintend the operation. The welding proper would have been a difficult operation, even under favorable conditions, while the hardships encountered due to the poor

[illegible] available and had to [illegible] the difficulties to be overcome.

With the material on the ground the first thought was to unbolt the [illegible] from the [illegible] and place it in a suitable position for welding. This was a long but easy job to accomplish as no time was lost in this work the heat provided was

of only about 2-ton capacity. At the expenditure of much time and trouble, however, the wheel was finally placed on the ground and the work of lining it up started. Right here more trouble was experienced owing to the fact that a very heavy rain fell during the day and so softened the ground that the fly-wheel would sink into the mud and it was practically impossible to jack it up. Jacks placed underneath it would simply sink out of sight. Eventually, however, it was blocked up and aligned up properly, but it was found that owing to its very great weight, it was slowly sinking, and it was necessary to build a platform on which to set the wheel before it could be permanently lined up ready for welding. A temporary roof was also constructed over it. An entire day was consumed in unloading the wheel and lining it up for welding. The next day, however, a rainstorm came up which softened the ground and necessitated aligning the wheel all over again, and the operation was not finished until the day following.

The repair of the fracture near the hub was made first, an opening of 2 in. being provided at the fracture, leaving just sufficient metal on the edges of the spoke to assist in aligning it. Provision was made for a collar 1½ in. in thickness at the center and 8 in. wide for which a welding portion was required consisting of 250 lb. of thermit, 62½ lb. of punchings, 5 lb. of ferrosilicon (80 per cent Si) and 2½ lb. of pure manganese.

In order to make these welds it was, of course, necessary to obtain compressed air, and this was done by running a pipe line a distance of about 400 ft. to a tannery in the village which boasted an air compressor, although when the original plans had been made for doing the work, it was figured that it would be necesary to obtain compressed air from one of the locomotives of the railroad.

Before pouring the thermit steel the adjacent spokes and hub were thoroughly heated to avoid too sudden cooling at the weld by conduction. Furthermore, as soon as possible after the pour a fire was built around the hub and spokes on both sides of the mold box to further assist in the slow cooling of the weld. This cooling operation was watched very carefully and required about 30 hours. The second weld was not attempted

FIG. 3.—TWO WELDS OF SPOKE.

until the first one had cooled thoroughly and was found to be in good condition.

The method of procedure in making the second weld was exactly the same as in the case of the first, as was also the size and composition of the welding portion, but owing to the fact that the weld could not contract freely, it was necessary to take even greater precautions in preheating and expanding the adjacent rim and spokes than was done in the first operation. Great care was also exercised in the annealing and upon the removal of the molds both welds were found to be perfect.

When the second weld was perfectly cold, preparations were made to weld the rim, and here further difficulities arose owing to the fact that it was necessary to change the position of the wheel and raise it up on its rim and revolve it until the fracture was on the ground. For this purpose a huge horse 20 ft. high, constructed of oak timbers, had first to be made, and this, together with all the tackle that it was possible to accumulate and with the aid of all the men in the vicinity, enabled the wheel to be lifted and revolved into position. An idea of the difficulty of this operation can be had from the illustrations and the fact that three days were required to accomplish it.

Having lined up the broken piece of the rim and fastened it in position by means of wrought-iron straps, which had been provided, the work of welding was carried on in the usual way. Provision was made for a thermit steel collar 6 in. wide

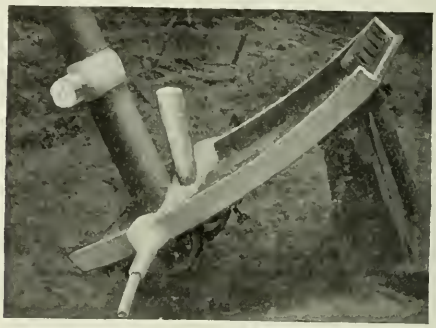


FIG. 4.—WELD ACROSS THE RIM.

and ¾ in. thick on the face of the rim and of the same width but 1¼ in. thick on the inside of the rim.

Owing to the fact that one of the spokes came directly out of the center of the wheel, it was deemed advisable to have a riser at that point, as the contraction there would be much greater, due to the heavy section of the spoke. Pouring gates and heating gates were provided at each edge of the rim, the pouring gates leading to a basin into which the crucible was tapped. The welding portion in this case consisted of 500 lb. of thermit, 125 lb. of punchings, 10 lb. of ferrosilicon and 5 lb. of pure manganese.

The melting out of the wax and proper preheating of this section required about five hours, using two preheaters, one on each side, and the pour consequently was not made until about 9:30 in the evening.

The same precautions were taken as regards preheating and provision for slow cooling and contraction as with the other welds, but about midnight a violent storm arose which continued until noon of the following day, and as it was practically impossible to build a roof over the wheel, it was subjected to this downpour of rain. The result was that the next morning a crack was found running longitudinally through the piece which had been welded on, running toward the thermit weld. This crack, however, as it ran lengthwise with the band of the wheel and not across it, did not materially affect the strength of the weld, and it was found to be practicable to repair it satisfactorily by putting on a patch. This was accordingly done, and the wheel returned to its owners.

An idea of the remote location of the town and the wretched facilities for doing work there can be gained from the fact that gasoline had to be obtained 50 miles away and all material had to be taken to the grocery store to be weighed, it being impossible to obtain a pair of scales.

Relation on the Character of Coals to the Prevention of Smoke.

An interesting paper on this subject was presented at the recent Syracuse meeting of the International Association for the

Prevention of Smoke by Mr. D. T. RANDALL, engineer in charge of the fuel engineering department of the Arthur D. Little Laboratories of Applied Chemistry in Boston.

The semi-bituminous and bituminous coals are the most extensively used of all the fuels which are available for generating steam. Containing as they do a considerable quantity of volatile matter which is given off when the coals are heated in the furnace, it is difficult to burn them under boilers so as to secure perfect combustion and freedom from smoke. Specially designed furnaces and careful operation are required to get good results.

The difference in the character of coals is only partly shown by the proximate analyses which are commonly used, but to one familiar with coals these analyses indicate in a general way the leading characteristics of the coals.

To show the difference in fuels the following table has been prepared:

TABLE I.

Analyses of Fuels as Delivered and Used.

	Coke.	Anthracite Pea Coal.	Pocahontas Coal.	Pittsburgh Coal.	Indiana Coal.
Moisture	4.67	4.75	1.12	2.48	9.62
Volatile matter	2.82	2.90	17.24	38.74	41.22
Fixed carbon	82.61	77.15	74.84	49.18	43.02
Ash	9.90	15.20	6.80	9.60	6.14
	100.00	100.00	100.00	100.00	100.00
Sulphur		0.89	0.71	1.85	4.43
B. t. u.	12,206	11,886	14,530	13,172	11,122

It will be noted that coals vary both in their composition and in their heating values (B.t.u.), and in consequence they are more or less valuable as fuel, depending on these variations.

Other things being equal, a fuel high in fixed carbon is more easily burned in a common furnace without loss of heat and without smoke than those of lower percentages. Coke and anthracite coals are examples of this class of fuels.

The percentage of moisture is not of great importance except in cases in which the coal is naturally high in moisture, or in which the coal is very wet as a result of washing or exposure to storms. Moisture in small percentages seems to aid combustion, but in larger amounts it retards the ignition of the gases and lowers the furnace temperature. It may or it may not increase the smoke, depending on the character of the fuel

The percentage of ash, and especially the character of the ash, is of importance in connection with the smoke problem. Ash which is fusible and runs down onto the grate bars may cause smoke by shutting off the flow of air through the fuel, and by increasing the poking which is necessary to keep the grates free Coals which clinker badly require more attention from the firemen, and poking the fire is a common cause of smoke.

There is a great difference in the behavior of the same coals when burned under different furnace conditions, and in different furnaces. Some grates and stokers are adapted to handle coals which are burned with great difficulty on other equipment

The rate of burning per square foot of grate is often the deciding factor as to whether a given coal may be used or not This is principally due to the higher temperatures which are obtained with high rates of combustion, and its effect on the fusible portion of the ash of the coal Investigations are now being made to determine the characteristics of the ash of representative coals as related to the clinker formed at various temperatures.

So far as smoke is concerned, the volatile matter is of the greatest importance. The quantity of volatile matter is not a true measure of the difficulty of burning a coal, but to one familiar with the various coal fields it is of great assistance in choosing a suitable coal or in designing a furnace suited to the given coal.

Investigations relating to the nature of volatile matter in representative coals have been carried on at the Government Fuel Testing Plant, at the University of Ohio and at the University of Illinois.

The results show that the differences in the gases given off from coals may be due to the composition of the coal and to the temperatures to which the coal is subjected when placed in the furnace. The higher temperatures tend to distill the volatile matter more rapidly and drive off the heavy hydrocarbon in forms which are difficult to burn without smoke

TABLE II

Absolute Quantities of Smoking Products in Ten Minutes' Heating at Different Temperatures.*

Coal	Temperature, Degs. C. Furnace	Gas	Smoking Products. Tar, Per Cent.	C_4H_8—c. c.
5 Connellsville	600	443	4.9	61
1 Ziegler, Ill	600	444	6.8	51
3 Connellsville	700	561	11.0	145
1 Ziegler	700	545	7.8	24
16 Pocahontas	700	599	4.2	138

*See paper by Porter & Ovitz in Journal of American Chemical Society, Vol. XXX.

The above table gives some idea of the complicated relation between the temperature of the coals in the furnace and the compositions of the various gases to be burned Investigations of this character are necessary to determine the characteristics of coals from each of the representative beds.

The combustion of coke or other fuels high in fixed carbon is comparatively simple. The greater portion of the fuel is burned on the grate; the remainder, in the form of gas, burns at a short distance above the bed of fuel. This may readily be observed on a fire of anthracite coal, in which there is only a small percentage of volatile matter

In burning bituminous coals, however, the difficulties are much greater, and for the reasons given above. The volatile matter from some coals is set free more readily than from others, and with some coals the nature of the volatile matter given off is such as to make it very difficult to secure complete combustion. Smoke is an indication of incomplete combustion, and the problem of reducing the amount of smoke is important, not only from the standpoint of the smoke inspector, but also because of the losses in combustible gases, such as carbon monoxide (CO) and hydrogen, which escape with the smoke

TABLE III

Showing Relation of Smoke to CO in Flue Gases.*

Average per cent of black smoke	0	7.1	15.5	24.7	34.7	43.1	52.9
Average per cent CO in flue gases	0.05	0.11	0.11	0.14	0.21	0.33	0.35
Number of tests averaged	37	18	56	51	36	17	4

*See U. S. Geological Survey Bulletin 325, pages 101 and 167

Experiments by several investigators have shown that whenever smoke is given off there is also a considerable quantity of carbon monoxide gas and that, as a rule, this gas is accompanied by small percentages of hydrogen and hydrocarbon compounds. The losses due to these combustible gases, which are found in connection with a smoky stack, may vary between 1 per cent and 10 per cent of the fuel

TABLE IV.

Showing Relation Between CO in Flue Gases and Other Combustible Gases.*

	Smoky				Clear			
	CO_2	CO	CH_4	H_2	CO_2	CO	CH_4	H_2
Boiler furnace	10.0	4.40	2.50	3.23	8.15	0.0	0.0	0.0
Hand fired.								

*See Manchester (England) Smoke Abatement Report.

When burning a bituminous coal, the volatile matter must be raised to a high temperature while mixed with a sufficient quantity of air and burned on its passage from the fuel bed to the surfaces of the boiler In most boiler settings this distance for combustion is very short, and when the gases strike the cold surfaces of the boiler shell or tubes they cool below the temperature at which they will burn rapidly, and, as a result, some escape unburned and others are only partially burned, as shown by the heavy deposits of soot. In properly designed furnaces the space provided for combustion is large for coals giving off high percentages of volatile combustible. Even in such furnaces the firing must be carefully done or no smoke through air cannot be supplied to the gases and smoke results for short periods. In most plants the time required for the gases to pass from the coal bed to the top of the stack is between 10 and 15 seconds, assuming the velocity to be reasonably uniform in different sections, then it will be seen that the gases pass from the coal bed to a furnace of only 1 to 10 per second At the

end of this period there is but little opportunity for the gases to burn. This will make clear the great importance of a sufficient air supply, properly distributed, and an ample space above or back of the grates in which the gases may thoroughly mix and burn within considerably less than one second of time.

That there is a loss due to the volatile gases escaping unburned from an ordinary furnace is shown very clearly by the results of tests made on house heating boilers. The following table gives figures obtained on two series of tests for the purpose of determining the fuel values of several coals and briquets,* when burned in a house-heating boiler.

TABLE V.

The Relation of Volatile Matter of Smoke and Unconsumed Gases.

Number of tests averaged.	Volatile matter in the combustible.	Ash in dry coal.	Efficiency.	Black smoke.	CO in dry flue gases.
4	18.30	8.00	50.56	18.2	0.44
7	22.71	8.94	56.33	18.0	0.50
7	34.70	11.27	54.11	22.1	0.55
11	38.79	15.02	47.19	30.8	0.62
16	44.40	14.57	47.19	32.9	0.74

The furnace in which the results shown in Table V were obtained is best suited to coke, anthracite or low volatile coals, and, as will be seen, is not adapted for burning bituminous coals with good efficiency, yet many furnaces having practically the same features, such as a grate surrounded by heating surface and a small combustion chamber, are used in power plants for burning high-volatile coals.

Even with furnaces of improved design it is difficult to charge the coal by hand-firing and secure smokeless combustion. This is due to the fact that a comparatively large quantity of gas is liberated immediately after firing at the same time the fuel bed has been thickened and the air enters with more difficulty and without being well distributed with respect to the gases rising from the bed. With such a furnace the loss of combustible gases may be reduced to 5 per cent or less, depending on the coal and the operation.

It is because of the advantage in having the coal gradually heated and the gases distilled from it at a low temperature that a mechanical means of feeding the coal to the furnace is usually more successful in the prevention of smoke.

A good furnace should permit the burning of bituminous coal in sufficient quantities without loss of escaping gases or the formation of smoke when the air supply is about 50 per cent in excess of the theoretical amount.

It has been found by experience that to approach this performance the coal must be fed regularly in small quantities, gradually heated, if possible, and the air supply admitted in such a way as to thoroughly mix with the distilled gases. Furthermore, the space for burning the gases should be large and preferably enclosed in firebrick.

A furnace suitable for certain coals may be entirely unsuited to other coals, and it is only after a careful study of all the factors, such as power to be generated, size and kind of boiler to be use, and the coals available, that an engineer can undertake to design a furnace which will be satisfactory and at the same time give good economy under operating conditions.

Tungsten.

On account of the recent depression in the steel industry the demand for tungsten, which is chiefly employed for tool steels, has been less in 1908 than in the preceding year. In 1908 the domestic production of tungsten ore, reduced to an equivalent of ore carrying 60 per cent of tungstic trioxide (WO_3), the ordinary commercial basis in the United States, was 671 short tons, valued at $229,955, as against 1640 tons, valued at $890,048, in 1907. The statistics at present available from foreign countries show a similar decline. These figures are taken from a report by F. L. Hess, of the United States Geological Survey, published in an advance chapter from "Mineral Resources of the United States, Calendar Year 1908." Mr. Hess gives also details of the industry by States, and a partial bibliography.

*See U. S. Geological Survey Bulletin No. 366.

The most important use of tungsten is for the manufacture of tool steels. There has been a widespread belief that most of the tungsten mined went into armor plate, but it is stated by the Ordnance Bureau of the Navy Department that tungsten is not now, and, so far as known to that bureau, never has been used in the manufacture of armor plate in this country, and it is not known to have been so used in other countries, though it has probably been used in experimental armor plates. One of the most essential properties of armor plate is its ability to resist shock, and this property is not imparted to steel by tungsten. Tungsten salts are used in fireproofing cloth for curtains, draperies, etc.; in weighting silks; in glass making; as a mordant in dyeing, and for other purposes. Tungsten is now also employed for the tungsten-filament lamp, the latest and most efficient incandescent lamp in commercial use.

Seamless Gasoline Tanks.

The cold-drawn seamless steel tank has solved the problem to find a high-pressure tank, free from danger, for gasoline or like substances. Since commercial gasoline contains always some acid, the steel tank must be provided with a lining which prevents corrosion. Zinc would be attacked by the acid, but tin is not.

The accompanying cut is an outside view of a cold-drawn seamless steel tank, tinned with pure block tin and tested to a hydrostatic pressure of 300 lb. per square inch, as placed on the market by Messrs. Janney, Steinmetz & Company, Philadelphia.

Notes.

An Aluminium Agreement.—The London *Electrical Review* states that the principal producers of aluminium have now arrived at an understanding only to proceed with sales for deliveries until the end of next March. The makers include the Neuhausen Aluminium Industry Company, the French works, with the exception of a small factory, the American works, and, it is said, the British Aluminium Company. It is believed in interested circles that the arrangement represents the preliminary step in the direction of reconstituting the international syndicate.

Thermit Process.—The British Corporation for the Survey and Registration of Shipping of Glasgow, after exhaustive tests, has sanctioned the use of the thermit process for repairs to fractured sternposts, lower portions of rudder frames and damages of a similar character.

Illuminating Gas.—The New York Section of the Society of Chemical Industry held a meeting on Nov. 19 at the Chemists' Club in New York City. The program was a symposium on illuminating gas by Dr. A. H. Elliott, Dr. E. G. Love, C. H. Stone and E. C. Uhlig.

Berlin Industrial Fair.—The Board of Trade of Berlin, N. H., has arranged a fair from Nov. 30 to Dec. 11 in order to endeavor to locate some new live industry in the city, and to advertise the city in general for industrial purposes. Berlin is already the seat of the Burgess Sulphite Fibre Company.

Canadian International Acheson Graphite Plant.—Another very substantial and commodious building is to be added to the Niagara Falls, Ont., branch works of the International Acheson Graphite Company. The structure is to be 50 ft. wide by 105 ft. long. The facilities afforded by this addition will make the Canadian works of the Graphite company quite complete in its ability to care for a rapidly growing trade, made so by Canada's industrial growth. The building will contain a new grinding plant, in which the lubricating, electrotype

and other grades of powdered graphite will be prepared for market. It will also contain a stockroom for package goods, such as graphited greases, powders, etc., while a new shipping room will make it most convenient for promptly filling orders.

Manganese Peroxide Anodes.—In the Lond. *Elec Eng'ing* of Oct. 14 we notice a recent British patent of the Siemens Brothers Company (605, Oct. 7, 1909) for anodes suitable for the electrolysis of zinc sulphate, sodium chloride and other solutions containing free acid, where it is important that the anode shall not be chemically attacked. According to this invention, the anode is formed of a plate of manganese peroxide produced by heating manganese nitrate in a mold. The plate is soaked in paraffin to prevent absorption of the electrolyte, and the end is coated with lead peroxide to provide a good contact.

The **American Blower Company** of Detroit, Mich., have sent us their new illustrated catalog No. 250 on "A B C" blowers for cupolas, forges, melting and heating furnaces, forced drafts, pneumatic tube systems and all other appliances where a strong, steady air pressure is required. Besides well-illustrated, concise descriptions of the latest types of their well-known pressure blowers, forge blowers, volume blowers, fan blowers, etc.; tables are given for determining the sizes of the blowers and proportioning the pipes for the same, with other miscellaneous tables of practical usefulness.

Mixing and Kneading Machinery.—A recent illustrated catalog of the Lynn-Superior Company, of Cincinnati, Ohio, describes mixing and blending machinery for paints, ink, pastes and semipastes, powders, blackings, polishes, greases, lubricating compounds, dental preparations, salts, medical compounds, stock powders, soaps and compounds of all kinds. There are 11 pages, each containing an illustration and brief description of a typical machine of this company, with a statement of capacities and dimensions.

Fluxes for Brass and Iron Foundries.—The necessity for using up borings and scrap of previous melts introduces an element of uncertainty into the mix, to overcome which purifiers have to be added. The United States Alloys Company, 1206 American Building, Baltimore, Md., are announcing a "Number One" (strong) and a "Number Two" (milder) flux which cleanse the metal bath of impurities by converting them into a fusible slag, which rises to the surface and is skimmed off. From ¼ per cent to ½ per cent is generally sufficient to eliminate iron, sand, dirt, grease, etc., from brass mixtures, even when present in considerable quantity. The metal may then be strengthened and a sound casting ensured in the usual way by the addition of a little manganese-copper or silicon-copper, or, in the case of iron castings, one of the ferro-alloys. The United States Alloys Company is prepared to furnish various guaranteed alloys and will ship 5-lb. and 10-lb. sample lots of fluxes without charge, express collect, to prospective customers.

Manganese-Silicon-Ferro.—Messrs. Dana & Co., 32 Broadway, New York, have issued a little pamphlet, entitled "Facts for the Expert Steel Maker" on a new manganese silicon-ferro alloy. It can be obtained in several grades. One typical analysis is 24.90 Si, 67.73 Mn, 0.091 P, 0.176 C, 0.012 S. Some of the advantages are the large reduction of the amount of impurities introduced with the ferro-alloy into the steel (especially the low-carbon content), the reduction of the loss of manganese by oxidation; it is non-explosive.

Sarco is the title of a "bulletin of power-plant practice," of which we have received No. 2 (October, 1909). It is issued by the Sarco Fuel Saving & Engineering Company, 90 West Street, New York, who make a specialty of CO_2 recorders, fuel calorimeters, blast-furnace charge recorders, draft gauges, pyrometers, etc. The bulletin contains some interesting articles. One entitled "Misinformation," criticizes some recent erroneous statements on the use of CO_2 recorder, the writer having stated that CO_2 recorder users should not attempt to get too high a CO_2 percentage and that 7 or 8 per cent CO_2 was already uneconomical. While it is true that users of CO_2 recorders frequently attempt to obtain impossibly high values of CO_2, this statement only becomes true when the percentage of CO_2 rises above 13 per cent. The illustrated article by Lewis Sanders on combustion of coal is continued. Then there are some "Don'ts for CO_2 recorder users." We quote a few of them: "Don't think that because you have a recorder in use it will reduce your coal bills unless you make use of the information given by the daily charts." "Don't try to operate the furnaces with less than 40 per cent excess air indicated by from 10 to 13 per cent CO_2, according to the volatile matter in the coal. You will be forming sufficient CO to counterbalance all the good effects of high CO_2."

Treatment of Timber for Underground Work.—It is estimated that mine operators of this country can save $12,000,000 a year by treating the timber used underground for props and decreasing the annual replacement necessary by delay from one-third of the total amount in use to one-thirteenth of the same amount. We quote Mr. W. F. Sherfesee, who says, in a new bulletin just issued by our active U. S. Forest Service: "The estimated life of an untreated mine prop is approximately three years. With a proper preservative treatment this life may be increased by approximately 10 years, giving a total life for the treated props of 13 years. All of the mine props, both round and square, in use in the United States, contain approximately 500-million cubic feet. About 40 per cent of this quantity, or 200-million cubic feet, can be advantageously treated. If no preservative methods were used the annual replacement of this 40 per cent would amount to one-third of 200 millions, or approximately, 67-million cubic feet of timber. If they were all given a proper preservative treatment the annual replacement would be reduced to one thirteenth of 200 million, or approximately, 15,300,000 cubic feet. Hence, by a proper preservative treatment of all mine timbers which can be treated advantageously, an annual saving would result of approximately 51,700,000 cubic feet, equivalent to 310,200,000 feet, board measure, or more than half of the present annual cut."

The **Denver Engineering Works Co.** announces the appointment of Walter H. Trask, Jr., as district sales manager at Salt Lake City, to succeed Carroll Helmick, resigned. Mr. Trask is a mechanical engineer, a graduate of the Massachusetts Institute of Technology and has been a salesman at the company's main office in Denver for the past two years.

Mr. **A. H. Reed** has resigned as engineer with the Independent Phosphate Company, Columbia, Tenn., to accept the position of local manager of the Rosiclare Fluorspar & Lead Mines, Rosiclare, Ill.

Messrs. **Pelton & Crane**, of Detroit, Mich., have just issued their 1910 electrical equipment catalog, chiefly for dentists' offices, with descriptions of electric dental furnaces, electric heaters for various purposes, etc.

Mr. **Arba B. Marvin** has opened an office at 950 Commercial National Bank Building, Chicago, Ill., as a solicitor of patents. Mr. Marvin is a graduate of the University of Wisconsin, he has been for a time instructor in electrochemistry at this University, and has made a special study of chemistry, electrochemistry and electrometallurgy. Mr. Marvin studied law at Columbian University, was for two years examiner in the U. S. Patent Office, and for the past five years he was assistant attorney in the patent department of the General Electric Company at Schenectady.

NEW BOOKS.

RICHARD RICE HAKEWELL. Text book of ore dressing. 150 pages. Price, $5 net. New York: McGraw-Hill Book Company.

RUDOLF RUDORF. Fundamentals of metallography. Authorized

translation by C. H. Matthewson. 342 pages. Price, $3 net. New York: John Wiley & Sons.

Low, Albert Howard. Technical methods of ore analysis. Fourth edition. 361 pages. Price, $3. New York: John Wiley & Sons.

Sellers, J. F. An elementary treatise on qualitative chemical analysis. Second edition, revised. 185 pages. Price, $1. Boston: Ginn.

Steinmetz, C. Proteus. Theoretical elements of electrical engineering. Third edition, revised. 464 pages. Price, $4 net. New York: McGraw-Hill Book Company.

McAllister, Addams Stratton. Alternating-current motors. Third edition, revised and enlarged. 334 pages. Price, $3 net. New York: McGraw-Hill Book Company.

Thomälen, Adolf. A text-book of electrical engineering. Translated from the German by G. W. O. Howe. Second edition. 472 pages. Price, $4.20 net. New York: Longmans, Green & Company.

Low, D. Allan. Applied mechanics; embracing strength and elasticity of materials, theory and design of structures, theory of machines and hydraulics; a text-book for engineering students; with 850 illustrations and 780 exercises. 558 pages. Price, $2.75. New York: Longmans, Green & Company.

Crawshaw, F. D. Metal Spinning. 80 pages, illustrated. Price, 25 cents. Chicago: Popular Mechanics Company

BOOK REVIEWS.

The Metallurgy of the Common Metals, Gold, Silver, Iron, Copper, Lead, and Zinc. By **Leonard S. Austin**, Professor of Metallurgy and Ore Dressing at the Michigan College of Mines. Second edition, revised and enlarged. 494 pages, 195 illustrations. Price, $4. San Francisco: Mining & Scientific Press.

The first edition of this work was reviewed in our volume VI, page 43. The fact that a second edition has become necessary only two years after the issue of the first edition proves that a book like this was needed.

The second edition has been revised and enlarged in many respects. The subject of thermochemistry, which forms a commendable feature of the book, has been expanded. The description of the cyanide process has been amplified and brought up to date, especially with respect to silver. The metallurgy of zinc has been treated more fully and particular attention given to the principles underlying the smelting of zinc ores. These and other changes and additions have undoubtedly greatly enhanced the usefulness of the work.

* * *

Radiation, Light and Illumination. A series of engineering lectures delivered at Union College. By **Charles Proteus Steinmetz**, A.M., Ph.D. Compiled and edited by Joseph LeRoy Hayden. 305 pages, illustrated. Price, $3 net. New York: McGraw-Hill Book Company.

The distinguished author, who has been aptly called the "Maxwell of alternating-current engineering," deals in this book with a new subject and speaks to a wider public. The work is "intended not merely as a text-book of illuminating engineering, nor as a text-book on the physics of light and radiation, but rather as an exposition, to some extent, from the engineering point of view, of that knowledge of light and radiation which every educated man should possess, the engineer as well as the physician or the user of light." For this reason mathematical formalism is avoided almost throughout the whole book and the phenomena are described in plain language.

There are 13 chapters, dealing with the nature and different forms of radiation, relation of bodies to radiation, physiological effects of radiation, chemical and physical effects of radiation, temperature radiation, luminescence, flames as illuminants, arc lamps and arc lighting, measurement of light and radiation, light flux and distribution, light intensity and illumination, illumination and illuminating engineering, physiological problems of illuminating engineering.

The subject is one with which everyone should be more or less acquainted, and Dr. Steinmetz's exposition of the subject is authoritative and masterful.

* * *

The Calculations of General Chemistry. With definitions, explanations and problems. By **William J. Hale**, Ph.D., assistant professor of chemistry in the University of Michigan. 174 pages. Price, $1 net. New York: D. Van Nostrand Company.

The training of the chemist must be twofold; he must learn to experiment and he must learn to interpret the results of experiments. Such interpretation requires simple mathematical calculations. Dr. Hale says in his preface: "The justification for a book of this character is to be found in the realization that many of the mathematical applications of our fundamental conceptions in chemistry, even upon the most elementary points, remain uncomprehended by students several years advanced in the study of the science." He thinks that it is "absolutely essential that more time be given in the college courses on general chemistry to these mathematical demonstrations. Unless a clear and concise exposition of the methods of calculation is presented in the very first course of college work, the progress of the student is greatly hindered."

Very properly Dr. Hale emphasizes, however, that chemical calculations should be associated, as much as possible, with experimental work. Hence, his book is intended to accompany the laboratory work in general chemistry and to help the student to a better understanding of the many possible conditions that may arise in the course of experimental work. The ideal plan, therefore, should be to associate these problems and their solutions with the actual laboratory practice.

We feel sure the book will be found useful for this purpose. It comprises no more than is presented by the author to students in their first year of chemistry at the university. But he hopes that at least the first portion of the book may have a helpful and profitable bearing upon the instruction of chemistry in high schools.

There are 12 chapters, dealing with units of measurement; density and specific gravity; the effect of pressure upon gases; the effect of temperature upon gases; the combined effect of pressure and temperature upon gases, partial pressures; Avogadro's hypothesis and some of its applications; the law of definite proportions; the derivation of chemical formulas; calculations depending upon chemical equations; normal solutions; combinations between gases by volume; complex equations.

In each chapter the principles are concisely stated and the general methods of calculations explained and illustrated by examples. At the end of each chapter a number of problems are given with answers, but without solutions. There are 275 such problems in the whole book.

* * *

Metallographia applicata a Prodotti Siderurgici. By Ingenieur **Umberto Savoia.** 16mo, VI+I and 208 pages, 94 illustrations. Price, 3.50 lire. (Retail price in New York, $1.25.) Milan: Ulrico Hoepli.

An Italian book is almost always well printed, on good paper, and in general a delight to the eye. The publishing house of Hoepli keeps up the reputation of Italy in this respect, but also in most commendable fashion it is publishing selected technical works such as will work wonders in advancing the scientific development of Italian industries. This work on "metallography applied to iron products" is carefully and accurately written (the microphotographs are particularly good), and will aid greatly in promoting the iron and steel industry in Italy, which will be largely electrometallurgical, there can be no doubt.

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